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C TECHNICAL REPORT 52-138

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AIR TO GROUND PROPAGATION MEASUREMENTS IN THE UHF BAND

RICHARD B. BATTELLE
COMMUNICATION AND NAVIGATION LABORATORY

JUNE 1952

WRIGHT AIR DEVELOPMENT CENTER

UNCLASSIFIED

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WADC TECHNICAL REPORT 52-138 [redacted]

AIR TO GROUND PROPAGATION MEASUREMENTS IN THE UHF BAND

Richard B. Battelle
Communication and Navigation Laboratory

June 1952

RDO No. 112-33

Wright Air Development Center
Air Research and Development Command
United States Air Force
Wright-Patterson Air Force Base, Ohio

McGregor & Werner, Inc., Wakefield, Mass.
Oct. 9, 1952 150

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FOREWORD

This report was prepared by the Antennas Unit of the Communication and Navigation Laboratory under Research and Development Order No. R-112-33, "Antennas for High Speed Aircraft," with Mr. R. B. Battelle acting as Project Engineer. Initial measurements were carried out by Mr. C. E. Ellis, formerly of the Antennas Unit, who developed the measurement techniques peculiar to these tests. Acknowledgement must also be given for the special cooperation and services of Captain J. K. Stuart of the Test Branch, Communication and Navigation Laboratory, who piloted all test flights, and the 162nd Fighter Squadron, Ohio Air National Guard, which made its facilities available for the level terrain tests at Vandalia, Ohio.

ABSTRACT

The Communication and Navigation Laboratory, WADC, has completed a series of flight tests to determine radiation and propagation limitations at UHF. Major emphasis was placed upon the variation of ground antenna radiation pattern as a result of antenna site and terrain characteristics. Antennas located on flat terrain were found to produce multiple lobe patterns, while elevated antennas on rolling terrain produced smooth free-space patterns. Propagation from both antenna sites can be predicted with reasonable accuracy using AIL type UHF coverage charts, from which the probable system performance also may be determined.

The security classification of the title of this report is UNCLASSIFIED.

PUBLICATION REVIEW

This report has been reviewed and is approved.

FOR THE COMMANDING GENERAL:

Daniel B. White

DANIEL B. WHITE
Colonel, USAF
Chief, Weapons Components Div

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AIR TO GROUND PROPAGATION MEASUREMENTS IN THE UHF BAND

INTRODUCTION

Radiation and propagation measurements have been carried out by the Antennas Unit, Communication and Navigation Laboratory. Particular attention has been paid to ground antenna radiation pattern characteristics because of the apparent discrepancy between similar measurements as made by the Naval Air Test Center, Patuxent River, Md.[1] and by the Rome Air Development Center, ARDC, Rome, N. Y.[2] The Naval Air Test Center found that reliable UHF communications from air to ground would be considerably limited by the deep nulls in the ground station antenna radiation pattern caused by the interference between the direct and the ground reflected signals. On the other hand, the Rome Air Development Center found that reliable communications could be maintained out to the radio line of sight range. It will be shown here that either condition can exist depending upon the peculiarities of the ground antenna site.

TEST CONDITIONS

All measurements made at the Wright Air Development Center used the following test set up:

Aircraft	- YF-94 No. 48-373
Airborne Antenna	- AT-256/ARC sleeve stub mounted under the fuselage at station 276, four inches to the right of the center line.
Transmission line	- Approximately 20 feet of RG-8/U
Transmitter	- Radio Set AN/ARC-19, Serial No. 18, transmitting continuously
Power output	- 5 watts at 379.4 mc, 8 watts at 240 mc.
Ground Station Receiver	- R-278/GRC (Part of Radio Set AN/GRC-27) with AVC voltage amplified for use with an Esterline-Angus recording voltmeter

Two antenna sites were used. As a typical air-base type of location on level terrain, permission was obtained to use the Ohio Air National Guard hanger at the Dayton Municipal Airport, Vandalia, Ohio. At this site, the terrain is relatively flat out to a considerable distance from the station. Antenna AT-197/GR discone was mounted 52 feet above the ground, and 135 feet of RG-8/U

1."Final Report on Ultra High Frequency Propagation Tests over Land and Water", U.S. Naval Air Test Center, Patuxent River, Maryland, dated 10 April 1951. (Restricted)

2."Summary of Ultra High Frequency Propagation Measurements over Land", Rome Air Development Center, Griffiss Air Force Base, Rome, N.Y. dated November 1951. (Restricted)

transmission line was used to feed the receiver. As typical of radar and d/f stations, a hilltop site at Building 117, WPAFB was used. This building is near the top of a 100 foot slope overlooking Wright and Patterson Fields. Numerous other buildings and installations are in the vicinity, and the terrain surrounding the airstrips themselves is rolling. Antenna AT-197/GR discone and Antenna Assembly AS-505/GR stacked vertical dipole array were mounted 50 feet above the ground and connected to the receiver through about 60 feet of RG-17/U transmission line. Measurements were recorded for flights west of the ground stations at altitudes of 5,000, 10,000, 20,000 and 35,000 feet. Ranges were measured using Radar Set AN/CPX-3 in conjunction with the airborne Radar Identification Set AN/APX-6. Normal VHF communications were maintained with the aircraft throughout each flight.

DISCUSSION OF RESULTS

Although ground antenna free space radiation patterns have been measured and relative gain determined, gain measurements were not immediately available of the airborne installation. Therefore, the Antenna Laboratory of Ohio State University was requested to measure the radiation patterns for an Antenna AT-256/ARC accurately scaled upon an F-94 aircraft model. Similar measurements of the more standard tail cap antenna showed that radiation below the horizon to the forward was considerably shadowed by the nose. The stub antenna under the fuselage showed no such shadows. Three principle plane patterns for the AT-256/ARC antenna at 240 and 379.4 mc full scale frequency are shown in Figures 1 and 2. The complete set of patterns was integrated for calculating the equivalent power isotropic circles shown. Near the horizon off the nose and tail, the antenna gain appears to be 2 to 4 db above an isotropic radiator.

In conjunction with the UHF antenna development program, the Airborne Instruments Laboratory, Mineola, N. Y. was requested to calculate UHF coverage charts for various ground and antenna conditions. These charts are utilized together with antenna gain measurements to derive theoretical curves of receiver voltage versus aircraft range.[1] These theoretical curves are plotted for comparison purposes beside each measured curve. The complete set of signal strength versus range curves for the ground station on level terrain is contained in Figures 3 to 18. At each altitude and frequency, two charts are shown: - one a plot of the measurements for outbound flight and one for inbound flight. At short ranges, only the envelope of the curve is indicated because rapid fluctuations of voltage make a more detailed plot impractical. A line-of-sight range, corrected for 4/3 radius earth, is also noted on each chart.

A brief explanation of the irregular pattern of the ground station antenna may be in order. Over flat terrain, the ground antenna receives the aircraft signal by two paths: - one, by a direct path and two, by reflection from the ground. The ground reflected ray, however, receives a phase delay as a result

1. AIL UHF coverage charts for various surface characteristics, antennas and frequencies are included as Fig. 27 to 42 of this report. Instructions for using these charts precede Figure 27.

of the longer distance traveled and the particular ground characteristics at the point of reflection. If this phase delay is 180, 540, 900, etc., degrees, the induced antenna voltages caused by the direct and reflected rays will be of opposite polarity, and cancellation will occur. As a result, a null in the radiation pattern can be expected at each radiation angle at which this cancellation takes place.

Figures 3 and 4 are curves for flights at 5,000 feet altitude using a frequency of 379.4 mc. The theoretical curves here differ only by the difference in the airborne antenna gain forward and aft. Since the gain is slightly greater to the rear of the aircraft, the outbound theoretical curve is slightly higher than the inbound curve at all altitudes. Both inbound and outbound flights show the pronounced dips in signal strength predicted by theory. Although the dips are not located exactly at the predicted ranges, the correlation between the curves is satisfactory. Errors in the location of the nulls are partly caused by the fact that the theoretical curves were calculated at the slightly lower frequency of 375.0 mc and partly by errors in aircraft altitude. Although the signal voltage is of the same order of magnitude as predicted, it is apparent that the measured signal is somewhat below the theoretical, especially as line-of-sight range is approached.

At 10,000 feet (Figures 5 and 6) the correlation between curves is particularly good. The nulls and voltage magnitudes are almost perfectly predicted by theory. Again, however, the drop-off of signal as maximum range is approached appears to be more rapid than expected. It is also noticeable here that at short ranges, the theoretical curve fails to predict measurements probably because of the deep nulls in the radiation pattern directly under the aircraft.

At 20,000 feet (Figures 7 and 8) the correlation is not quite as good. The same is true for the 35,000 foot flight shown in Figures 9 and 10. The general trend of the difference between theoretical and measured curves, however, appear to be signal voltages somewhat less than predicted and nulls slightly deeper than predicted.

At 240 mc, it will be found that there are fewer nulls in the radiation pattern and generally higher signal voltages than found at 379.4 mc. Figures 11 and 12 show the results of the 5,000 foot flight. Again, the more rapid than predicted attenuation of signal with increased range is noticed. Nulls again appear to be deeper than the theoretical curve predicts. At 10,000 feet, Figures 13 and 14 indicate similar conclusions. The extreme depth of the nulls is particularly noticeable in Figures 15 and 16 for the flights at 20,000 feet. Here, although the correlation is quite good, the deepest null actually dropped the signal voltage far into the noise.

An effort to explain this for the flight at 35,000 feet altitude has been made in Figures 17 and 18. Most of these measurements were made during the winter weather of January and February 1952. On some flight days, a light snow covered the ground and thus somewhat modified the ground constants. For these 35,000 feet graphs, the theoretical curves for flight over Arctic regions at 40,000 feet altitude are also included. Since the magnitudes of the maximums

and minimum are more extreme for the arctic ground surface, the correlation appears to be slightly better at all except short ranges. The modification of the altitude for the arctic surface curve was necessary to match null location, although an error of 5,000 feet seems unlikely. Probably a variance of both the surface constants and the altitude was the cause of errors in the prediction here.

The effects of lobe structure in the ground station antenna pattern have been quite pronounced in this series of graphs. Assuming no other losses, an operational system having the same set up as measured here would probably be considered to be tolerably good if not perfectly satisfactory. Unfortunately, the depth and width of the pattern nulls leave little if any safety factor for absorbing additional system losses.

Contrary to level terrain theory which predicts deep nulls in the ground radiation pattern, no such nulls appear in the curves plotted for flights from a hilltop ground station. Figures 19 and 20 are curves of receiver input voltage versus aircraft range for flight at 35,000 feet altitude when the ground station was located at Building No. 117 at the top of a 100 foot hill overlooking Wright Field. For these first two curves, Antenna AT-197/GR discone was used. Free space curves which include aircraft and ground antenna gains are plotted for purposes of comparison. Except for a few unexplained dips in the curves, the measured voltages closely follow the theoretical free space curves without the least suggestion of the typical level terrain type pattern. Note, however, that variations in the measured curves average about 9 db with some dips dropping as much as 18 db. These fluctuations in voltage are particularly detrimental at short ranges where the multiple lobe structure, usually expected for an elevated antenna, becomes more serious.

When Antenna Assembly AS-505/GR stacked dipole array is used, as shown in Figures 21 and 22, the fluctuations in signal strength are considerably less violent at ranges between twenty and sixty miles. However, signal strengths are lower at short ranges where the fluctuations are just as extreme as with the AT-197/GR antenna. Nevertheless, the fact that the general signal level is higher and somewhat smoother than that obtained for the AT-197/GR seems to favor the AS-505/GR to some extent.

At 240 mc similar results are shown in Figures 23 to 26, for the two antenna types at the hilltop location. Again, the most pronounced effect of the AS-505/GR was the smoother curve at twenty to sixty miles range and the general increase in signal level by about 4 db.

It is probable that the smooth character of these curves is a result of the multiple reflection of the aircraft signal from the rough terrain. Basically, if these reflections are numerous and of random phase, they will add up vectorially to zero voltage, leaving only the direct ray to induce a voltage on the antenna. This reasoning seems to explain in brief the correlation between these curves and the theoretical free space curve.

The comparatively smooth measured curves plotted for these flights indicate that an operational system using a hilltop ground site of this type would provide

normally satisfactory communications, assuming no additional losses. Except for the extreme signal fluctuations which must be tolerated for aircraft directly overhead, signal voltages can be expected to remain well above the minimum usable voltage out to full communications range. It should be noted, however, that at no time during these tests did the signal remain strong out to radio line-of-sight range.

This flight data can form a basis for analyzing the probable effectiveness of the UHF system as a whole. Assume first an ideal installation:

Airborne transmitter power output	15 Watts
Ground receiver sensitivity (for readable signal)	1 Microvolt
Total transmission line losses	1.5 db at 240 mc 2.0 db at 379.4 mc

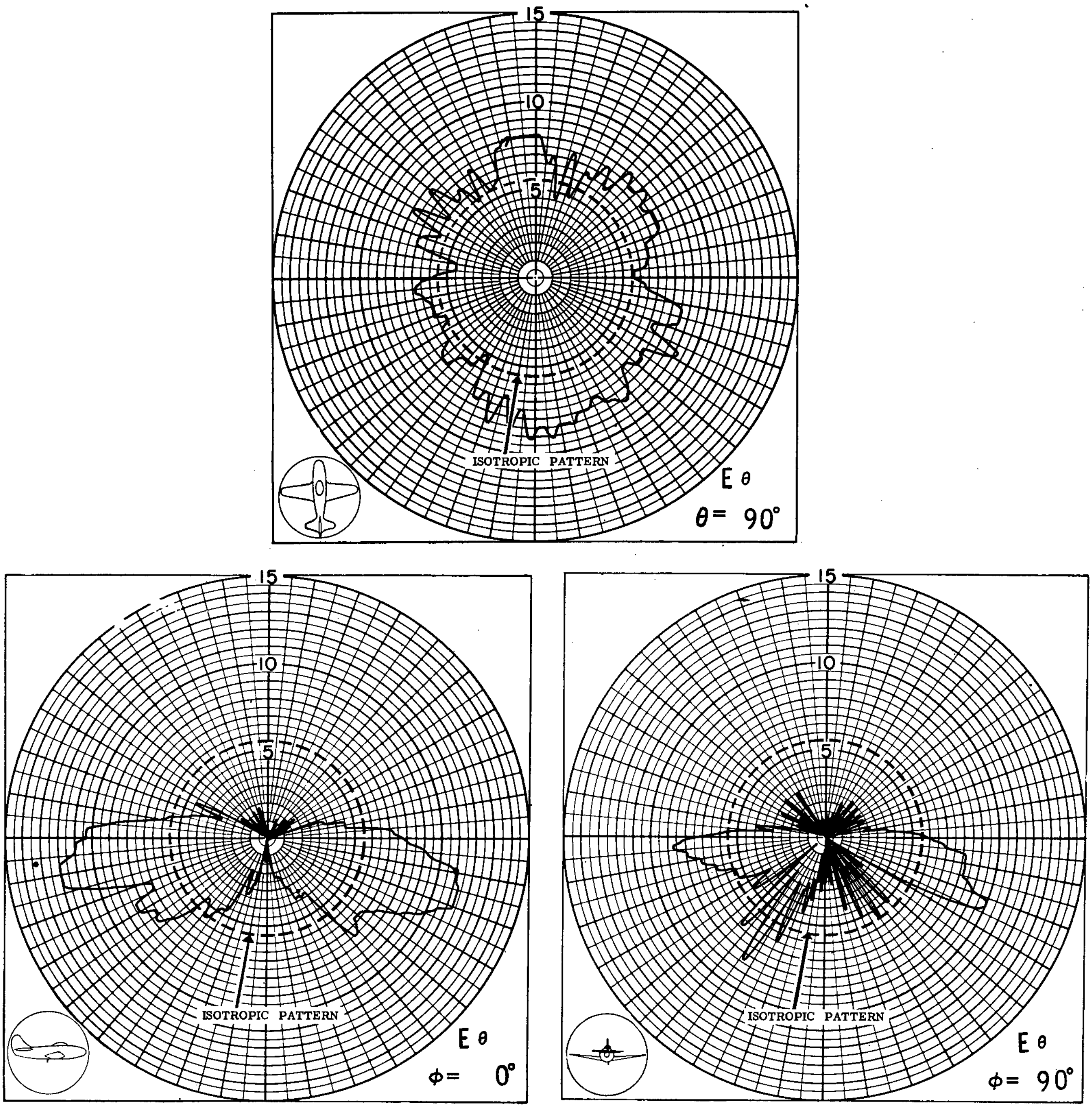
This system is considerably better than the system used for these flight tests. In comparison to the test conditions used for the level terrain measurements plotted in Figures 3 to 18, this ideal system is 6.6 db better at 240 mc and 10.3 db better at 379.4 mc. Undoubtedly, gapless communications would result with an F-94 flying out and inbound as in the tests. In fact, since no serious holes exist in the aircraft pattern at the horizon, gapless communications can be expected for the aircraft flying straight and level in any direction within maximum range. However, when operation is considered with the aircraft in other than level flight, there may be some difficulty. Notice in Figures 1 and 2 that there are serious nulls in the radiation pattern just above and below the horizon. At UHF, such nulls are more the rule than the exception since reflecting and shadowing surfaces are larger with respect to the wavelength. These nulls may result in signal strengths 20 to 40 db below the signal voltage for an equivalent isotropic radiator. These nulls were noted frequently during the tests described here. They were apparent during all circles flown by the pilot and during normal flight when the pilot banked to check his ground position. Such tremendous losses completely swamp out the slight advantage which a perfect UHF system has over the system tested here.

Actually, the fact is that the present UHF equipment cannot be assumed to always operate with perfect characteristics. To mention a few sources of imperfection to be expected, transmitter power output tubes become weaker with use, and alignment is not precise on all channels; and transmission line losses become greater particularly in aircraft where the equipment cannot be located near the antenna and the primary supply voltage may drop below normal; all these factors result in lower radiated power. 6 db system loss would not be unusual from these sources. On the ground, not only is there the usual loss associated with poor tubes and alignment and lengthy transmission line, but squelch operation will reduce receiver sensitivity to more or less extent depending upon the setup of the receiver and the local noise level. Compared to the perfect one microvolt system, such an operational setup could normally be expected to be poorer by as much as 15 db. These assumed figures are not unreasonable, yet without considering the added loss caused by radiation pattern nulls, the system is found to be considerably poorer than the test system measured here.

Summarizing these factors which determine the probable extremes between a perfect and a poor UHF system, it will be found that system performance may be somewhat better than measured here. Actually, a perfect system could be expected to produce signal voltages 6 to 10 db above those shown in the graphs, while a poor system must be expected to perform as much as 20 db worse than the system measured here. Aircraft maneuvers will cause deterioration as great as 20 to 40 db in addition to the losses already accounted for.

CONCLUSIONS

It has been shown that UHF propagation can be predicted with reasonable accuracy using the AIL type UHF coverage charts if the ground antenna site is located on level terrain. When the terrain is rolling or rough and the antenna location is on a hilltop site, the propagation can be predicted by free-space curves, also drawn in the AIL charts. The results of these measurements indicate that air to ground UHF communications will be generally satisfactory for level flight if equipment is maintained in perfect operating condition and losses are at a minimum. The added losses caused by sub-standard equipment and installations will not result in serious difficulty for level flight if a hilltop ground station on rolling terrain is used. However, such losses will cause a serious deterioration in performance if the ground antenna site must be located on level terrain. Nulls in the airborne antenna radiation pattern will cause considerable losses resulting in marginal performance during aircraft maneuvers regardless of ground antenna site and equipment condition.



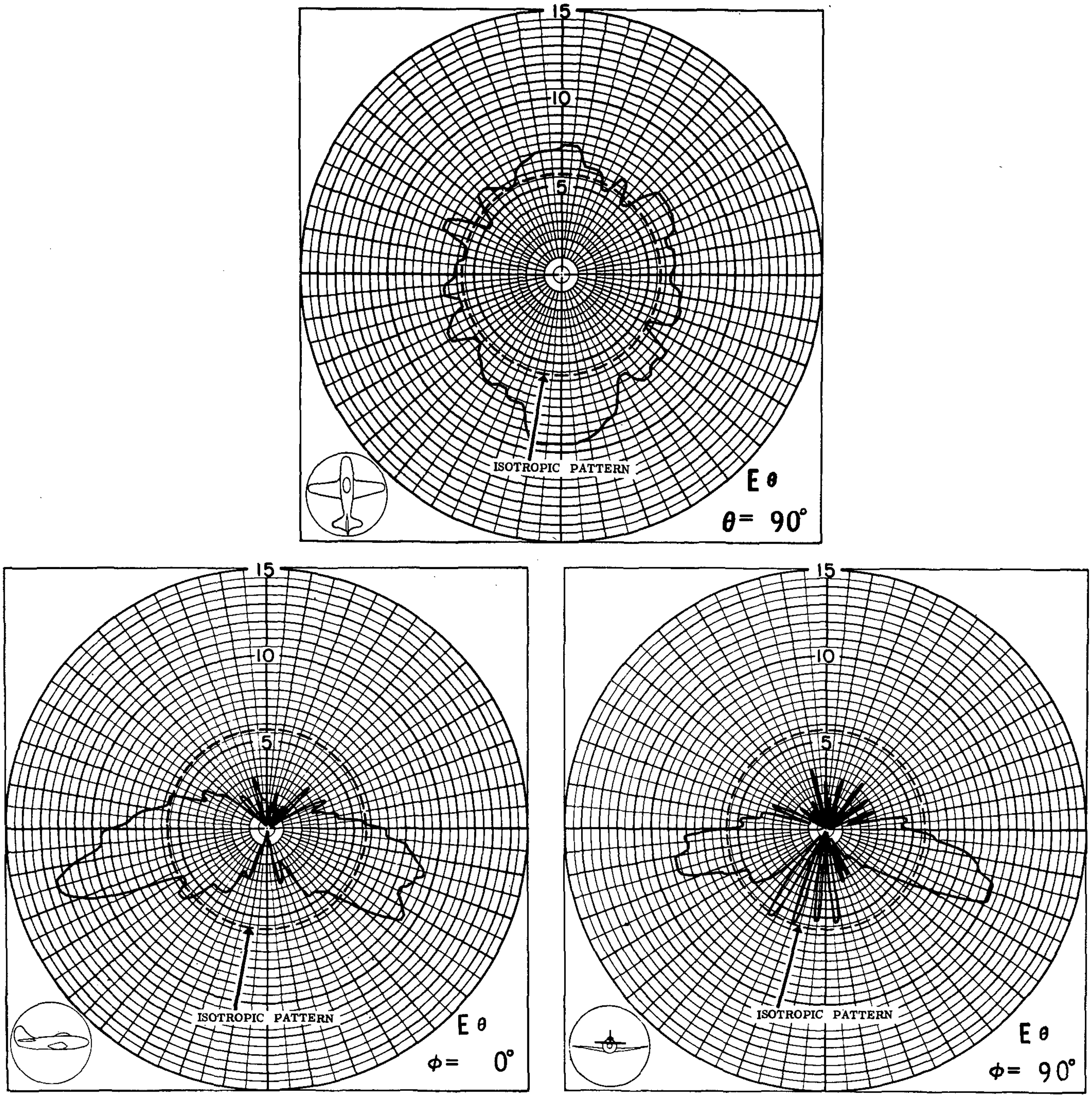
MODEL F-94 SIMULATED FREQUENCY 379.4 mc

SCALE 1/20 MODEL FREQUENCY 7588 mc (λ = 3.953 cm)

COMPONENTS E_ϕ (HORIZONTAL) E_θ (VERTICAL)

REMARKS AT-256/ARC sleeve-stub antenna mounted at station 276 four inches to right of bottom center line of fuselage.

Figure 1. Principle Plane Radiation Patterns for F-94 Aircraft - 379.4 mc.



MODEL **F-94** SIMULATED FREQUENCY 240 mc

SCALE 1/20 MODEL FREQUENCY 4800 mc (λ = 6.25 cm)

COMPONENTS E_ϕ (HORIZONTAL) E_θ (VERTICAL)

REMARKS AT-256/ARC sleeve-stub antenna mounted at station 276 four inches to right of bottom center line of fuselage.

Figure 2. Principle Plane Radiation Patterns for F-94 Aircraft - 240.0 mc.

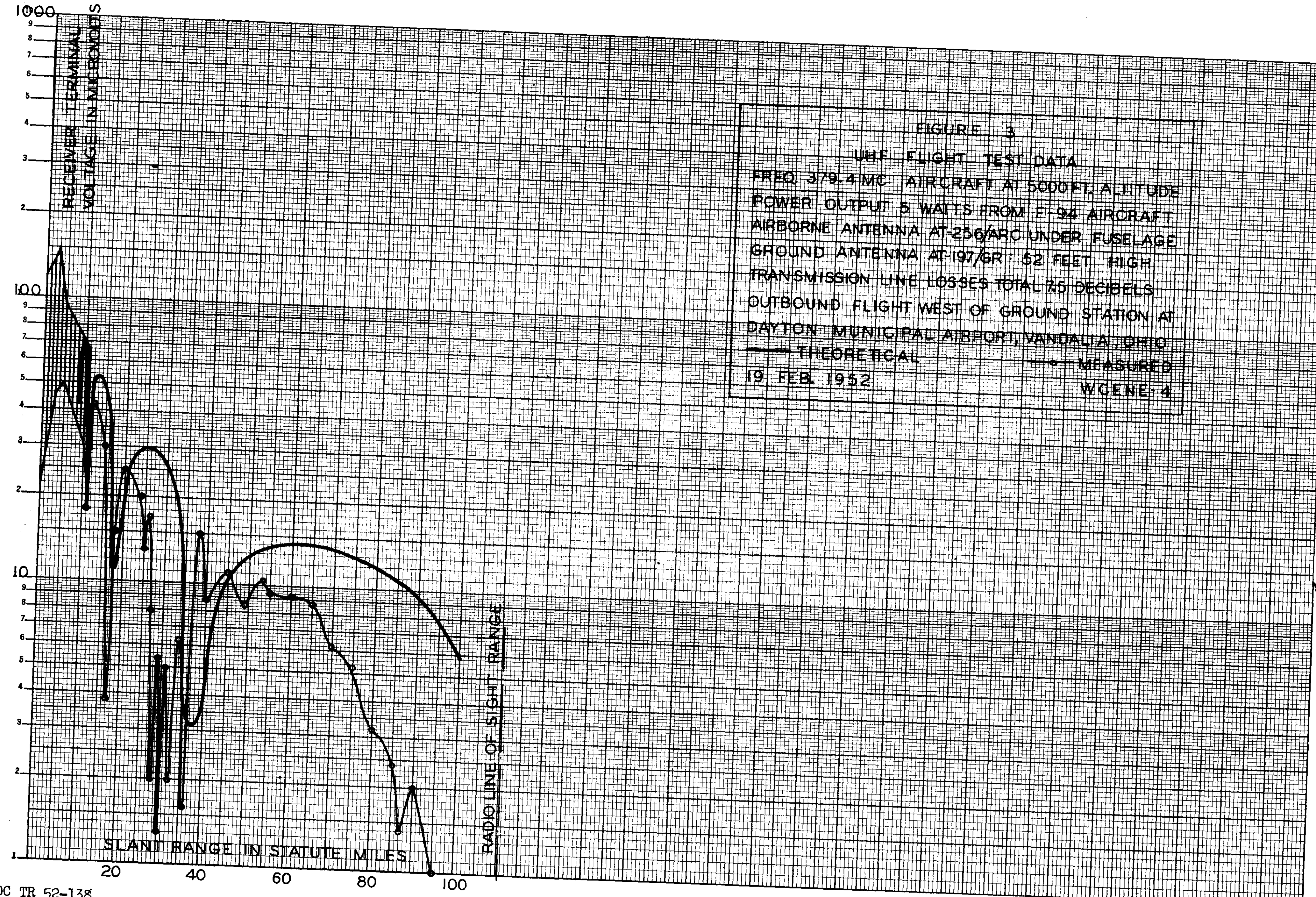


FIGURE 3
UHF FLIGHT TEST DATA
FREQ. 379.4 MC AIRCRAFT AT 5000 FT. ALTITUDE
POWER OUTPUT 5 WATTS FROM F-94 AIRCRAFT
AIRBORNE ANTENNA AT-256/ARC UNDER FUSELAGE
GROUND ANTENNA AT-197/GR: 52 FEET HIGH
TRANSMISSION LINE LOSSES TOTAL 7.5 DECIBELS
OUTBOUND FLIGHT WEST OF GROUND STATION AT
DAYTON MUNICIPAL AIRPORT, VANDALIA, OHIO
THEORETICAL
MEASURED
19 FEB. 1952
WCENE-4
RECEIVER TERMINAL VOLTAGE IN MICROVOLTS
1000
100
10
1
SLANT RANGE IN STATUTE MILES
20
40
60
80
100
RADIO LINE OF SIGHT RANGE

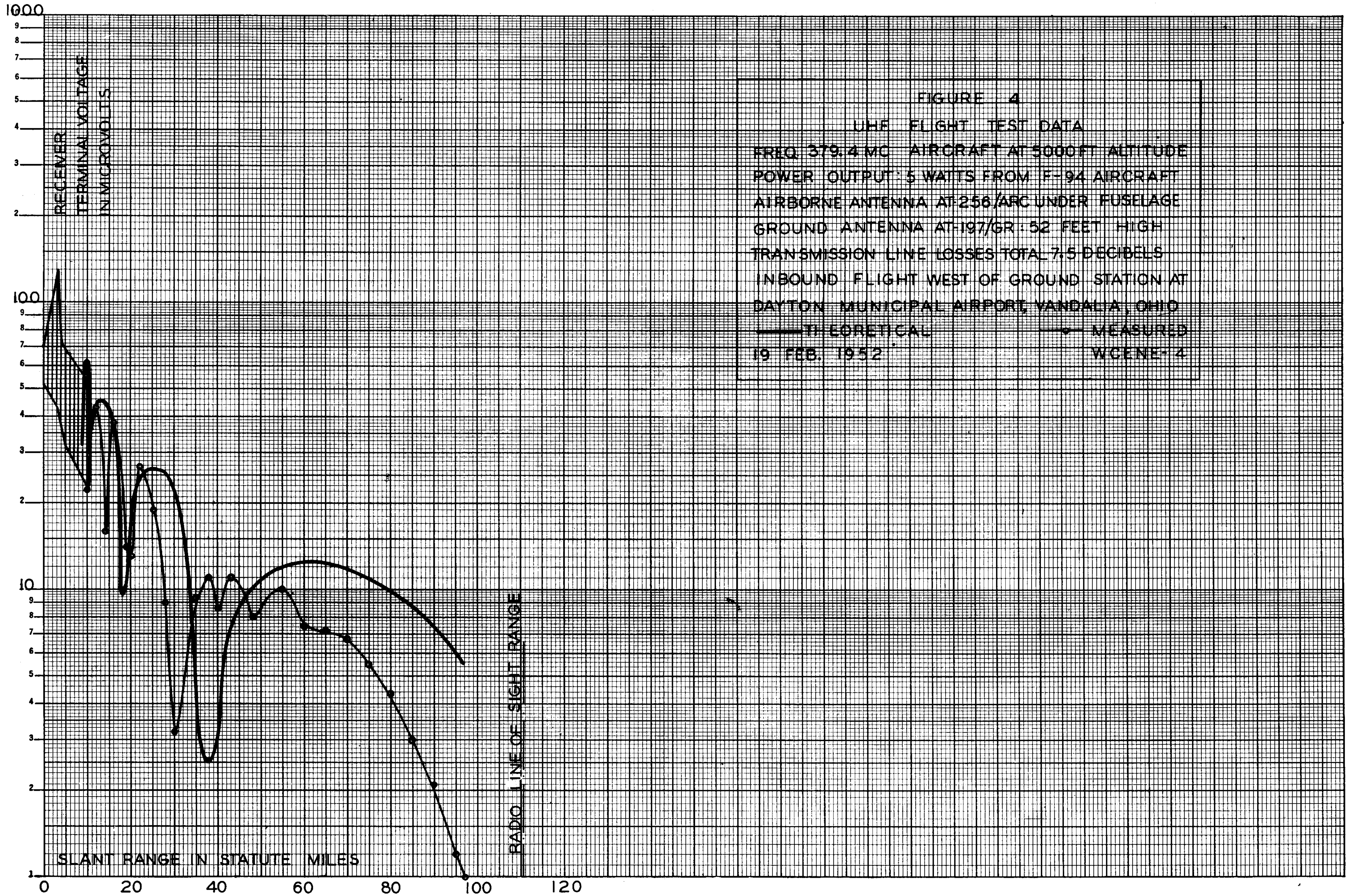


FIGURE 4
UHF FLIGHT TEST DATA
FREQ. 379.4 MC AIRCRAFT AT 5000 FT ALTITUDE
POWER OUTPUT 5 WATTS FROM F-94 AIRCRAFT
AIRBORNE ANTENNA AT-256/ARC UNDER FUSELAGE
GROUND ANTENNA AT-197/GR: 52 FEET HIGH
TRANSMISSION LINE LOSSES TOTAL 7.5 DECIBELS
INBOUND FLIGHT WEST OF GROUND STATION AT
DAYTON MUNICIPAL AIRPORT, VANDALIA, OHIO
THEORETICAL
MEASURED
19 FEB. 1952
WCENE-4
RECEIVER TERMINAL VOLTAGE IN MICROVOLTS
SLANT RANGE IN STATUTE MILES
RADIO LINE OF SIGHT RANGE
1000
100
10
1
0
20
40
60
80
100
120

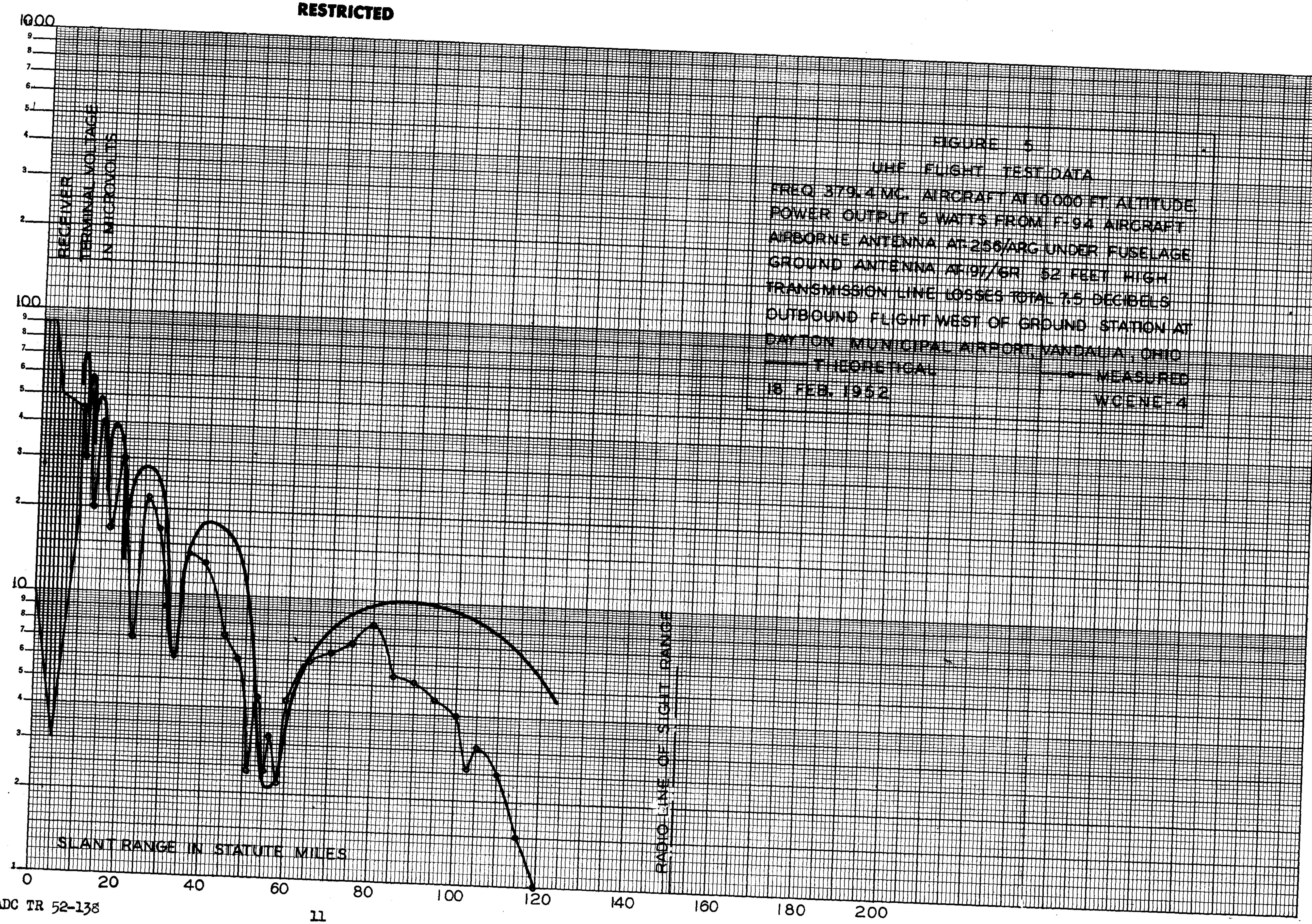


FIGURE 5
UHF FLIGHT TEST DATA
FREQ. 379.4 MC. AIRCRAFT AT 10,000 FT. ALTITUDE
POWER OUTPUT 5 WATTS FROM F-94 AIRCRAFT
AIRBORNE ANTENNA AT-256/ARC UNDER FUSELAGE
GROUND ANTENNA AT-197/GR 52 FEET HIGH
TRANSMISSION LINE LOSSES TOTAL 7.5 DECIBELS
OUTBOUND FLIGHT WEST OF GROUND STATION AT
DAYTON MUNICIPAL AIRPORT, VANDALIA, OHIO
THEORETICAL
MEASURED
18 FEB. 1952
WCENE-4
RECEIVER TERMINAL VOLTAGE IN MICROVOLTS
SLANT RANGE IN STATUTE MILES
RADIO LINE OF SIGHT RANGE
1000
100
10
1
0
20
40
60
80
100
120
140
160
180
200

9

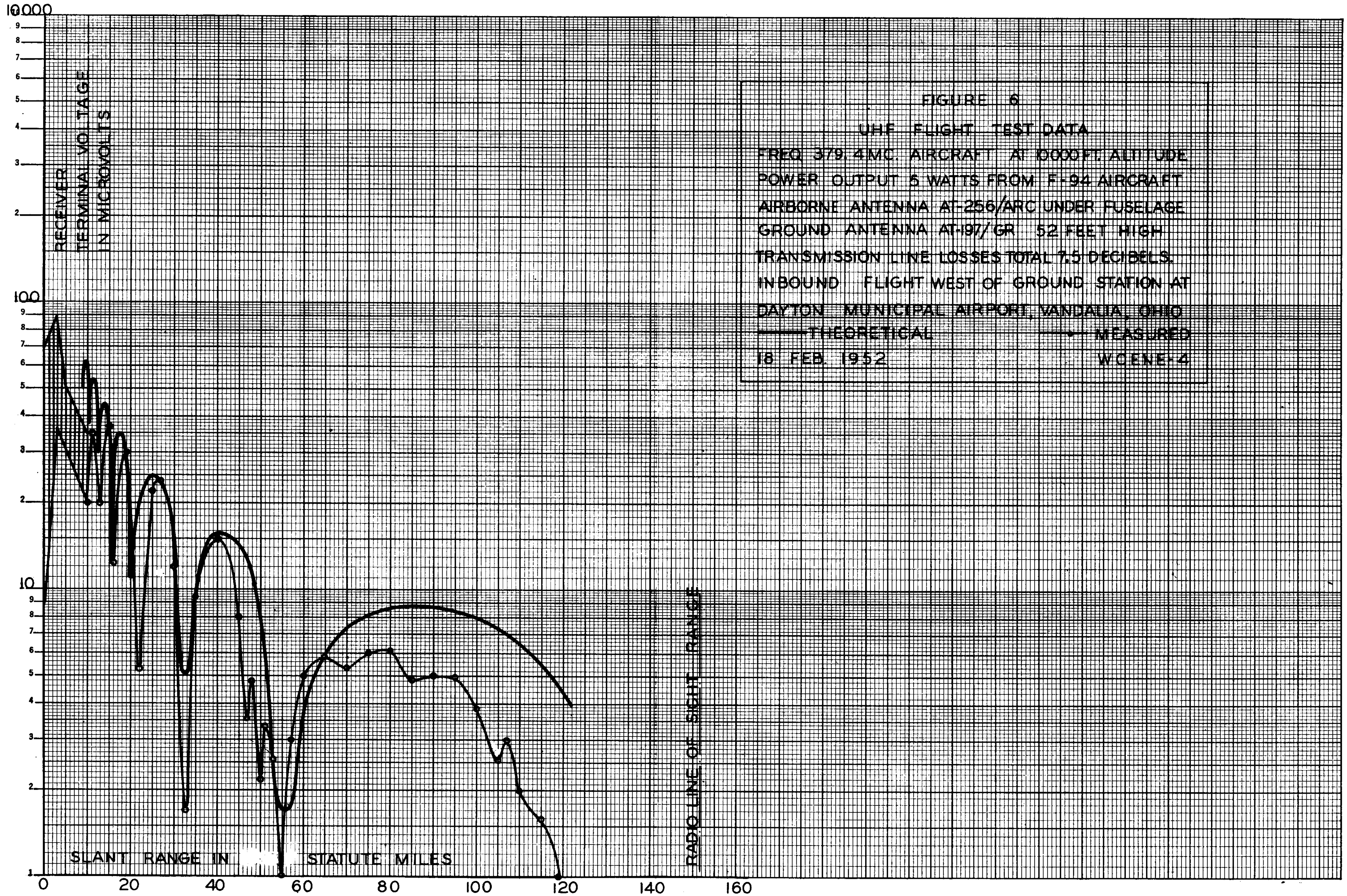


FIGURE 6
UHF FLIGHT TEST DATA
FREQ 379.4MC. AIRCRAFT AT 10000 FT. ALTITUDE
POWER OUTPUT 5 WATTS FROM F-94 AIRCRAFT
AIRBORNE ANTENNA AT-256/ARC UNDER FUSELAGE
GROUND ANTENNA AT-197/GR 52 FEET HIGH
TRANSMISSION LINE LOSSES TOTAL 7.5 DECIBELS.
INBOUND FLIGHT WEST OF GROUND STATION AT
DAYTON MUNICIPAL AIRPORT, VANDALIA, OHIO
THEORETICAL
MEASURED
18 FEB. 1952
WCENE-4
RECEIVER TERMINAL VOLTAGE IN MICROVOLTS
SLANT RANGE IN STATUTE MILES
RADIO LINE OF SIGHT RANGE
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0
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80
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120
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160

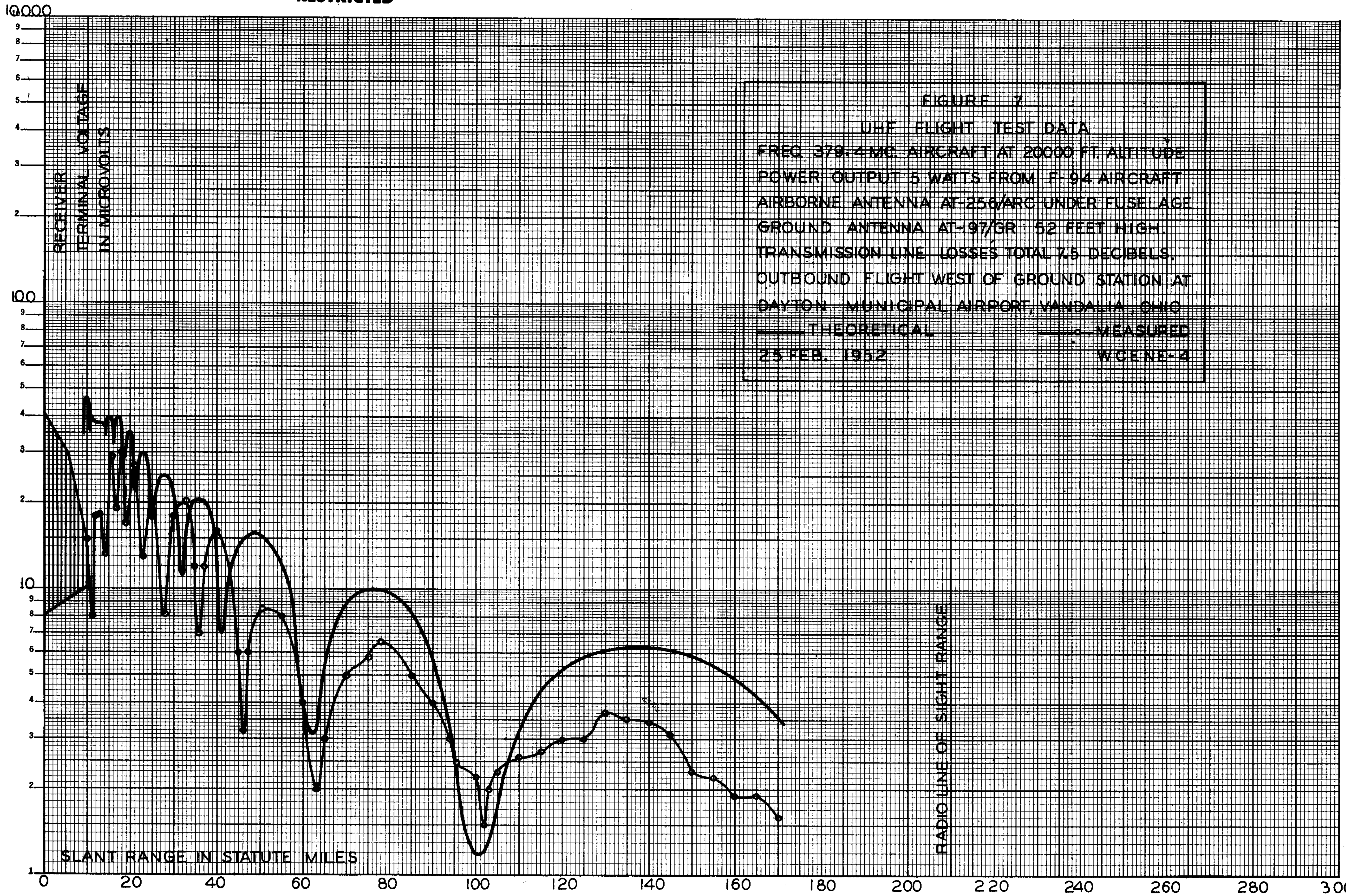

FIGURE 7
UHF FLIGHT TEST DATA
FREQ. 379.4 MC. AIRCRAFT AT 20000 FT. ALTITUDE
POWER OUTPUT 5 WATTS FROM F-94 AIRCRAFT
AIRBORNE ANTENNA AT-256/ARC UNDER FUSELAGE
GROUND ANTENNA AT-197/GR 52 FEET HIGH.
TRANSMISSION LINE LOSSES TOTAL 7.5 DECIBELS.
OUTBOUND FLIGHT WEST OF GROUND STATION AT
DAYTON MUNICIPAL AIRPORT, VANDALIA, OHIO
THEORETICAL
MEASURED
25 FEB. 1952
WCENE-4
RECEIVER TERMINAL VOLTAGE IN MICROVOLTS
SLANT RANGE IN STATUTE MILES
RADIO LINE OF SIGHT RANGE
10,000
100
10
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0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300

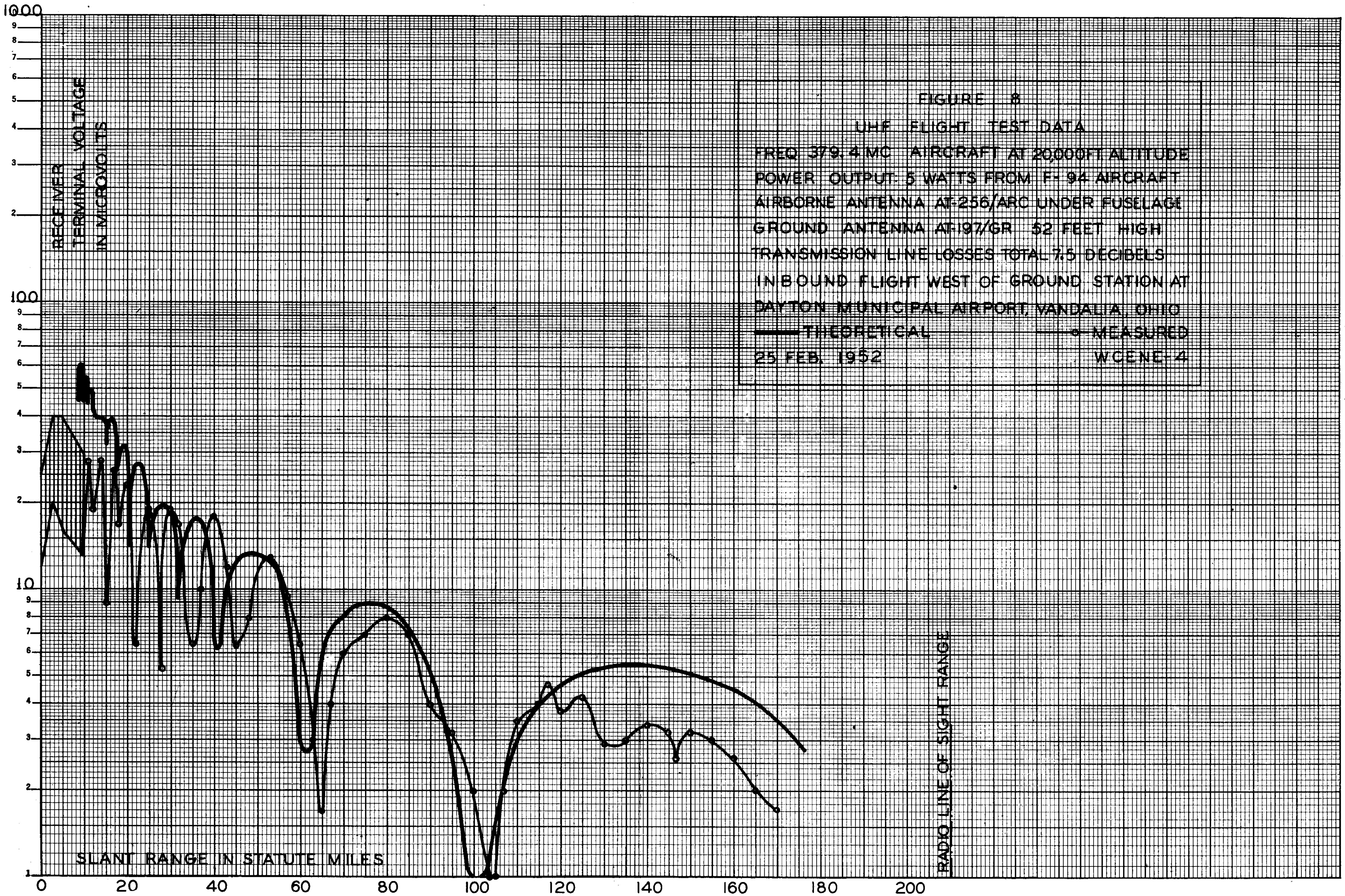
FIGURE 8
UHF FLIGHT TEST DATA
FREQ 379.4 MC AIRCRAFT AT 20,000FT ALTITUDE
POWER OUTPUT 5 WATTS FROM F-94 AIRCRAFT
AIRBORNE ANTENNA AT-256/ARC UNDER FUSELAGE
GROUND ANTENNA AT-197/GR 52 FEET HIGH
TRANSMISSION LINE LOSSES TOTAL 7.5 DECIBELS
INBOUND FLIGHT WEST OF GROUND STATION AT
DAYTON MUNICIPAL AIRPORT, VANDALIA, OHIO
THEORETICAL
MEASURED
25 FEB. 1952
WCENE-4
RECEIVER TERMINAL VOLTAGE IN MICROVOLTS
SLANT RANGE IN STATUTE MILES
RADIO LINE OF SIGHT RANGE
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100
10
1
0
20
40
60
80
100
120
140
160
180
200

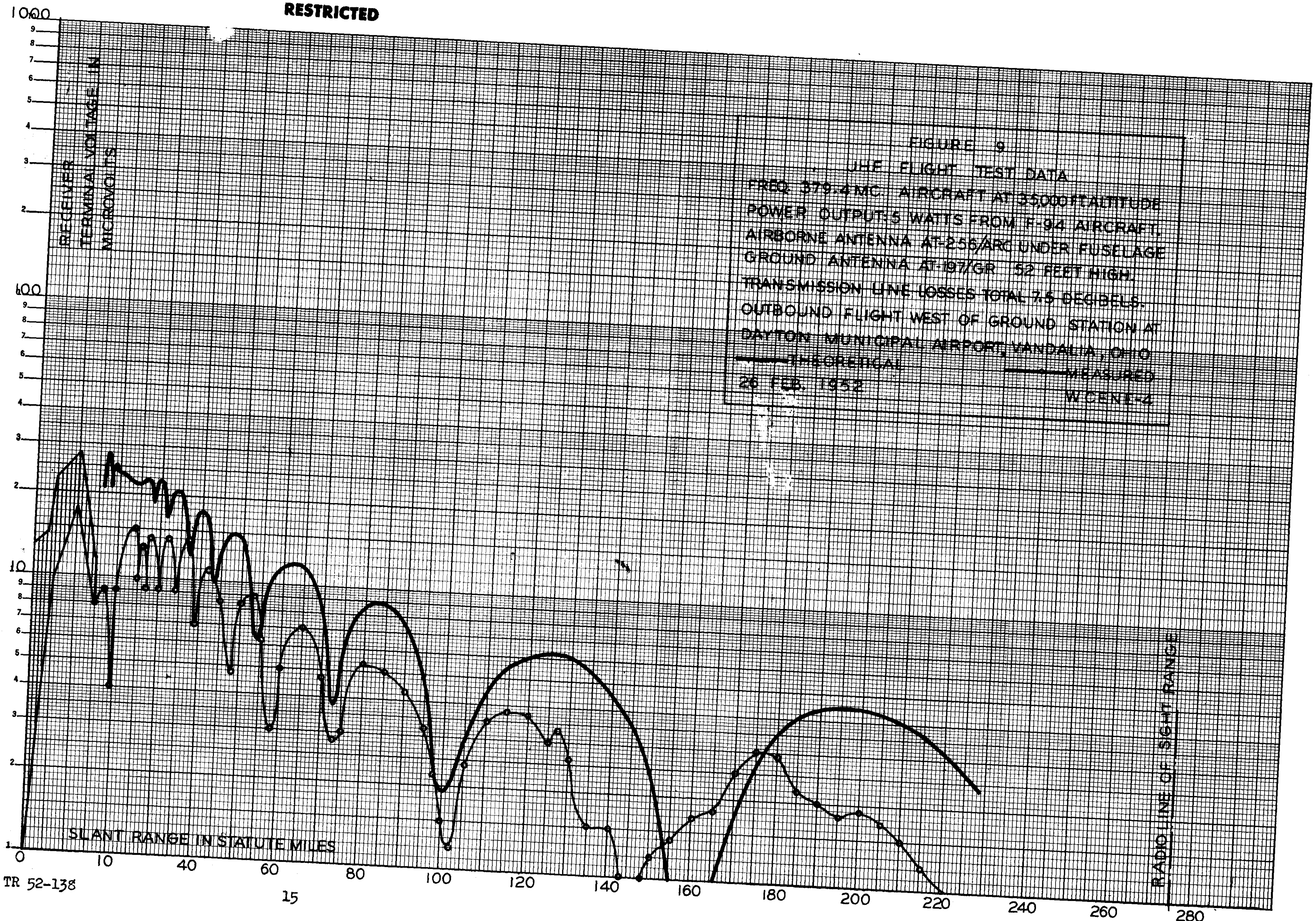
FIGURE 9
UHF FLIGHT TEST DATA
FREQ. 379.4 MC. AIRCRAFT AT 35,000 FT. ALTITUDE
POWER OUTPUT: 5 WATTS FROM F-94 AIRCRAFT.
AIRBORNE ANTENNA AT-256/ARC UNDER FUSELAGE
GROUND ANTENNA AT-197/GR 52 FEET HIGH.
TRANSMISSION LINE LOSSES TOTAL 7.5 DECIBELS.
OUTBOUND FLIGHT WEST OF GROUND STATION AT
DAYTON MUNICIPAL AIRPORT, VANDALIA, OHIO
THEORETICAL
MEASURED
26 FEB. 1952
W.CENT-4
RECEIVER TERMINAL VOLTAGE IN MICROVOLTS
SLANT RANGE IN STATUTE MILES
RADIO LINE OF SIGHT RANGE
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100
10
1
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280

2

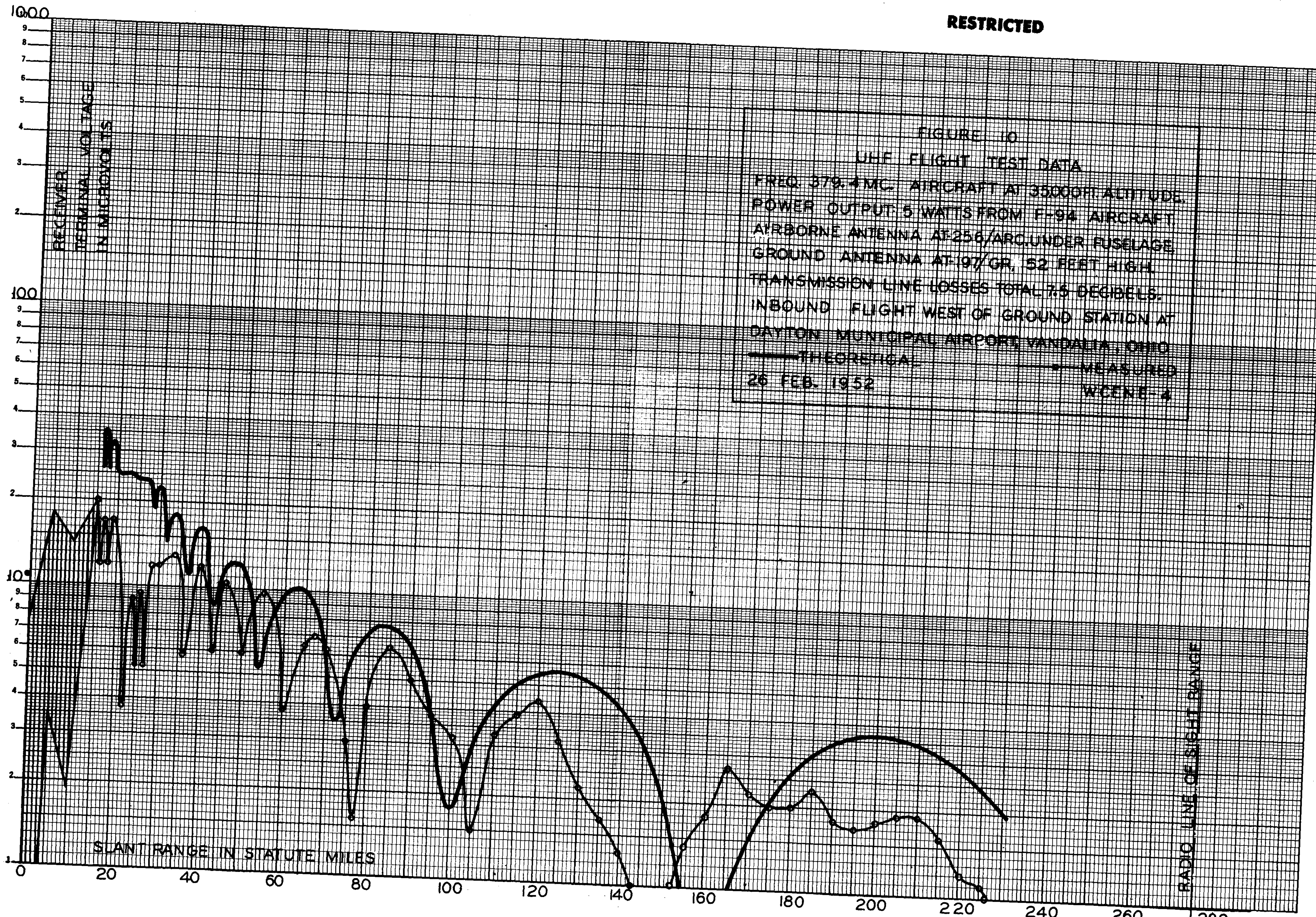
FIGURE 10
UHF FLIGHT TEST DATA
FREQ. 379.4 MC. AIRCRAFT AT 35000 FT. ALTITUDE.
POWER OUTPUT 5 WATTS FROM F-94 AIRCRAFT
AIRBORNE ANTENNA AT-256/ARC UNDER FUSELAGE
GROUND ANTENNA AT-197/GR, 52 FEET HIGH.
TRANSMISSION LINE LOSSES TOTAL 7.5 DECIBELS.
INBOUND FLIGHT WEST OF GROUND STATION AT
DAYTON MUNICIPAL AIRPORT, VANDALIA, OHIO
THEORETICAL
MEASURED
26 FEB. 1952
WCENE-4
RECEIVER TERMINAL VOLTAGE IN MICROVOLTS
SLANT RANGE IN STATUTE MILES
RADIO LINE OF SIGHT RANGE
1000
100
10
1
0
20
40
60
80
100
120
140
160
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200
220
240
260
280

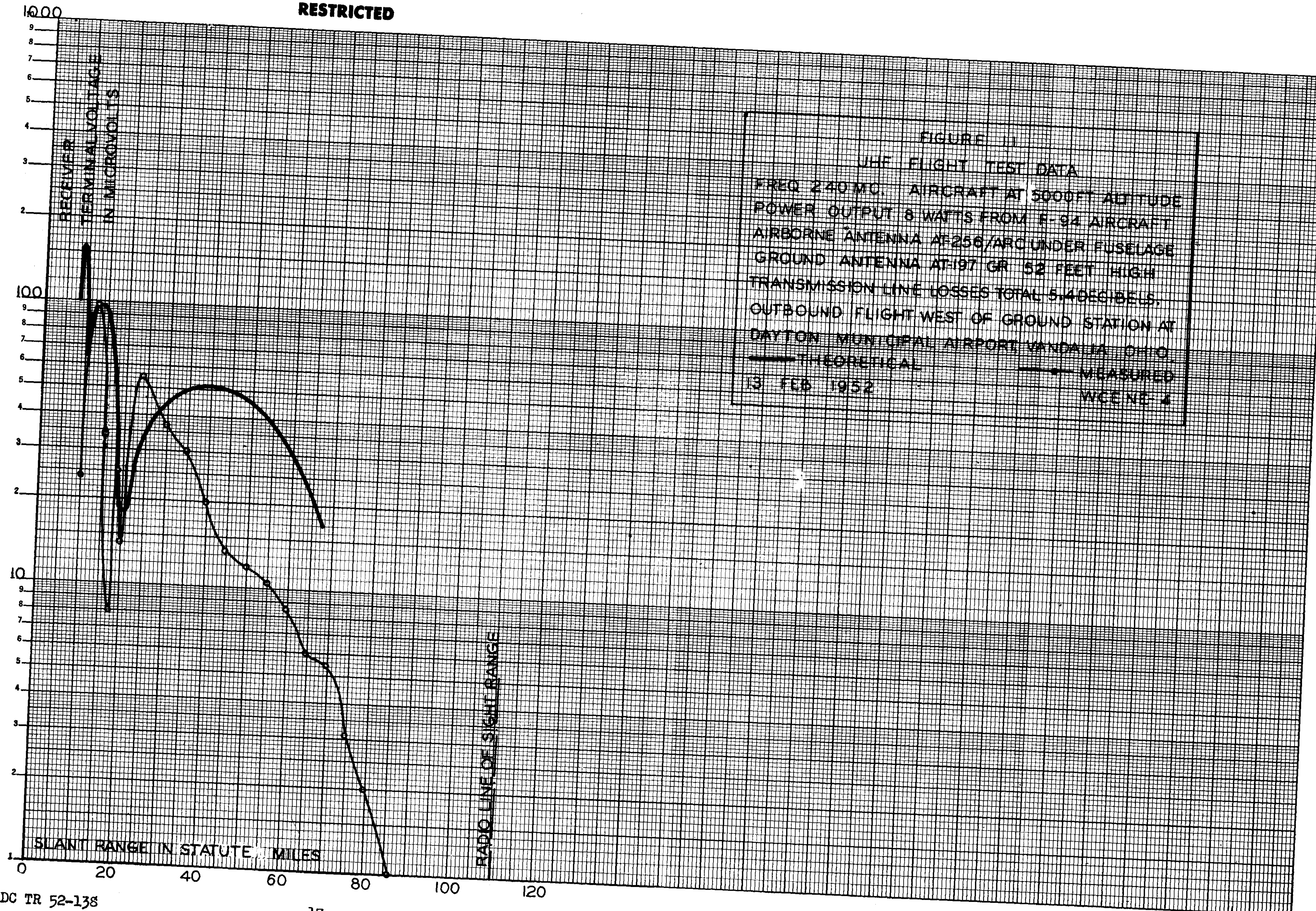
FIGURE 11
UHF FLIGHT TEST DATA
FREQ 240 MC. AIRCRAFT AT 5000FT ALTITUDE
POWER OUTPUT 8 WATTS FROM F-94 AIRCRAFT
AIRBORNE ANTENNA AT-256/ARC UNDER FUSELAGE
GROUND ANTENNA AT-197 GR 52 FEET HIGH
TRANSMISSION LINE LOSSES TOTAL 5.4DECIBELS.
OUTBOUND FLIGHT WEST OF GROUND STATION AT
DAYTON MUNICIPAL AIRPORT VANDALIA OHIO.
THEORETICAL
MEASURED
13 FEB 1952
WCENE-4
RECEIVER TERMINAL VOLTAGE IN MICROVOLTS
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10
1
RADIO LINE OF SIGHT RANGE
SLANT RANGE IN STATUTE MILES
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40
60
80
100
120

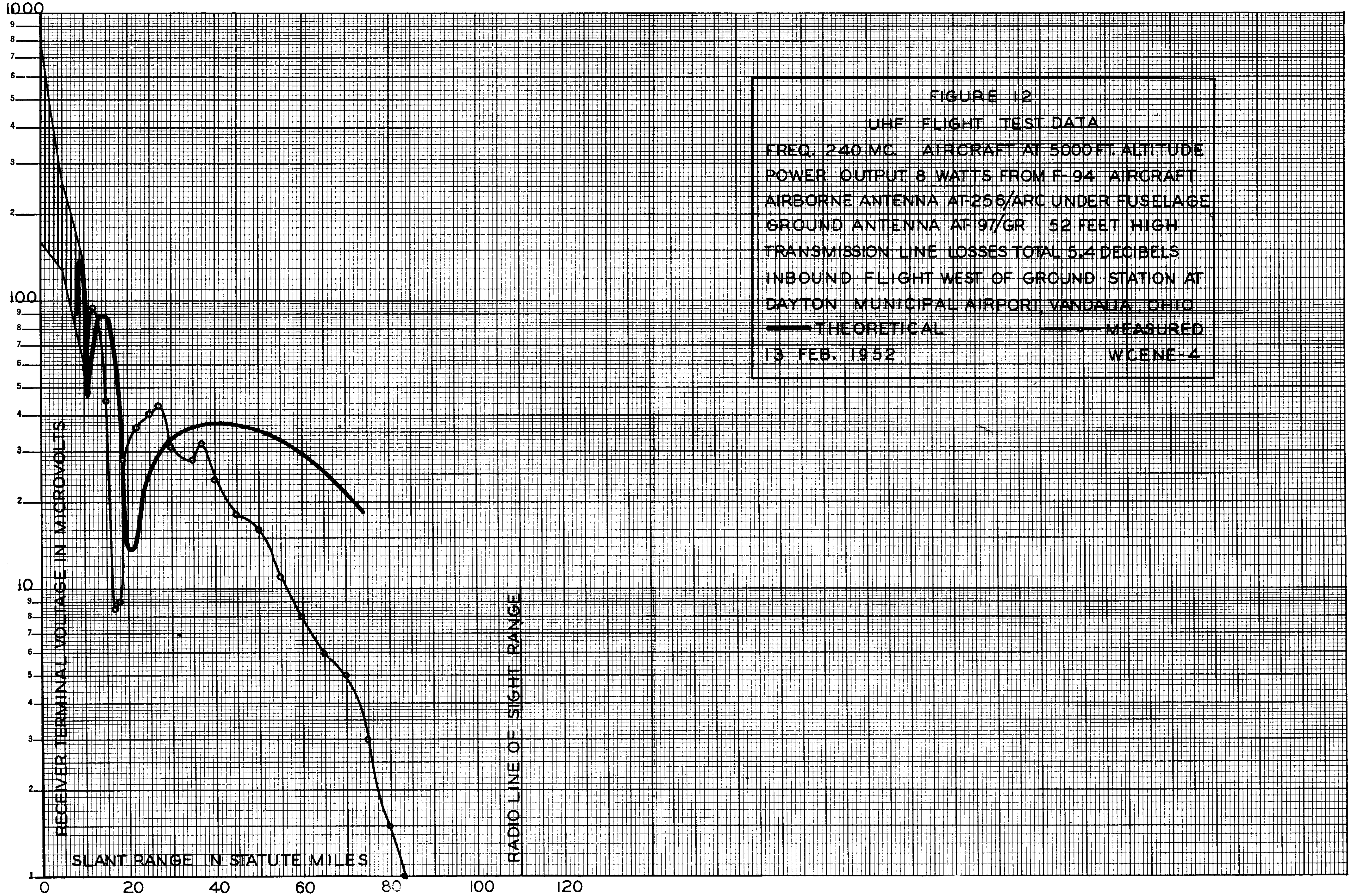


FIGURE 12
UHF FLIGHT TEST DATA
FREQ. 240 MC. AIRCRAFT AT 5000 FT. ALTITUDE
POWER OUTPUT 8 WATTS FROM F-94 AIRCRAFT
AIRBORNE ANTENNA AT-256/ARC UNDER FUSELAGE
GROUND ANTENNA AT-97/GR 52 FEET HIGH
TRANSMISSION LINE LOSSES TOTAL 5.4 DECIBELS
INBOUND FLIGHT WEST OF GROUND STATION AT
DAYTON MUNICIPAL AIRPORT, VANDALIA, OHIO
THEORETICAL
MEASURED
13 FEB. 1952
WCENE-4
RECEIVER TERMINAL VOLTAGE IN MICROVOLTS
SLANT RANGE IN STATUTE MILES
RADIO LINE OF SIGHT RANGE
1000
100
10
1
0
20
40
60
80
100
120

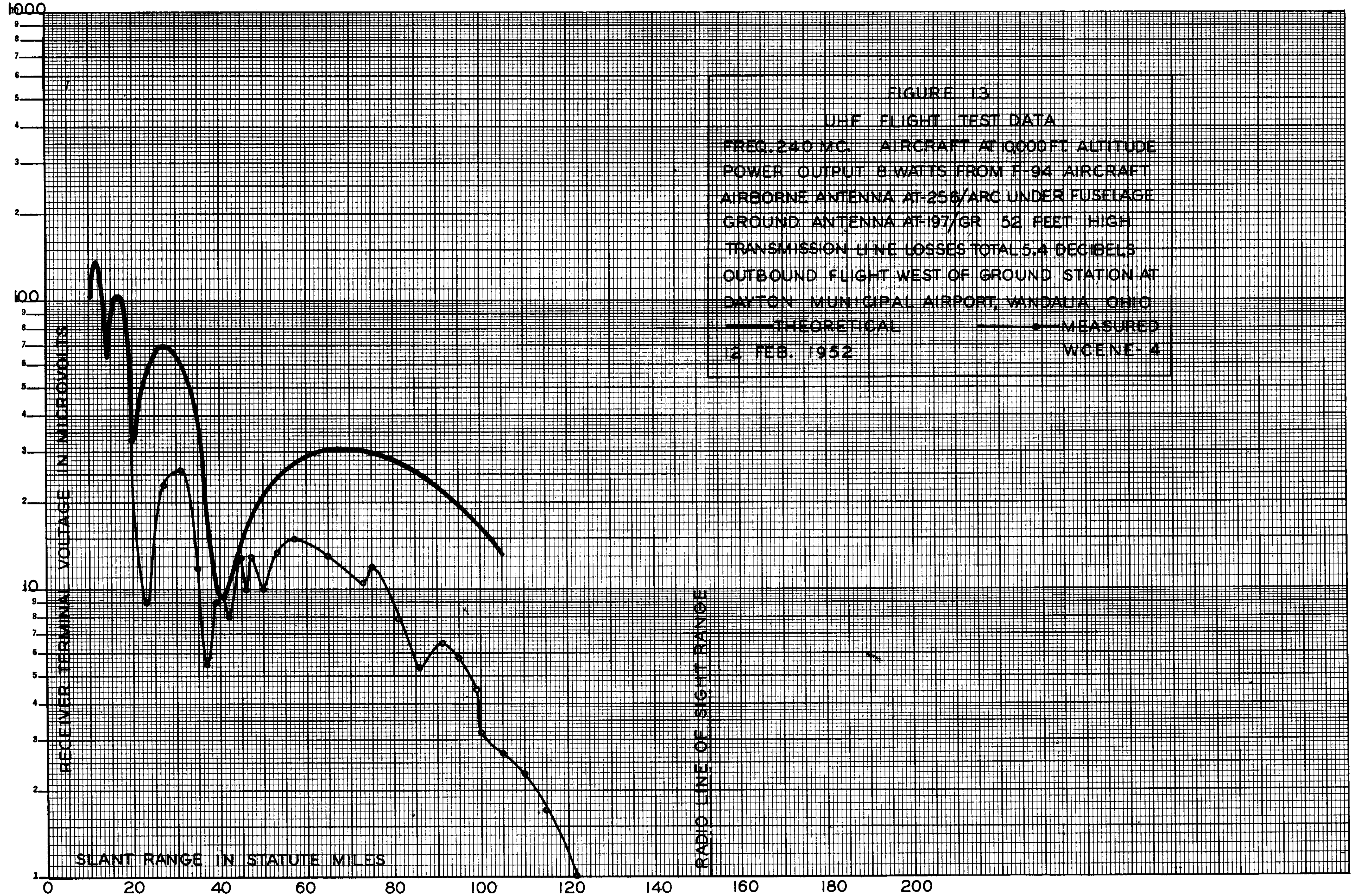


FIGURE 13
UHF FLIGHT TEST DATA

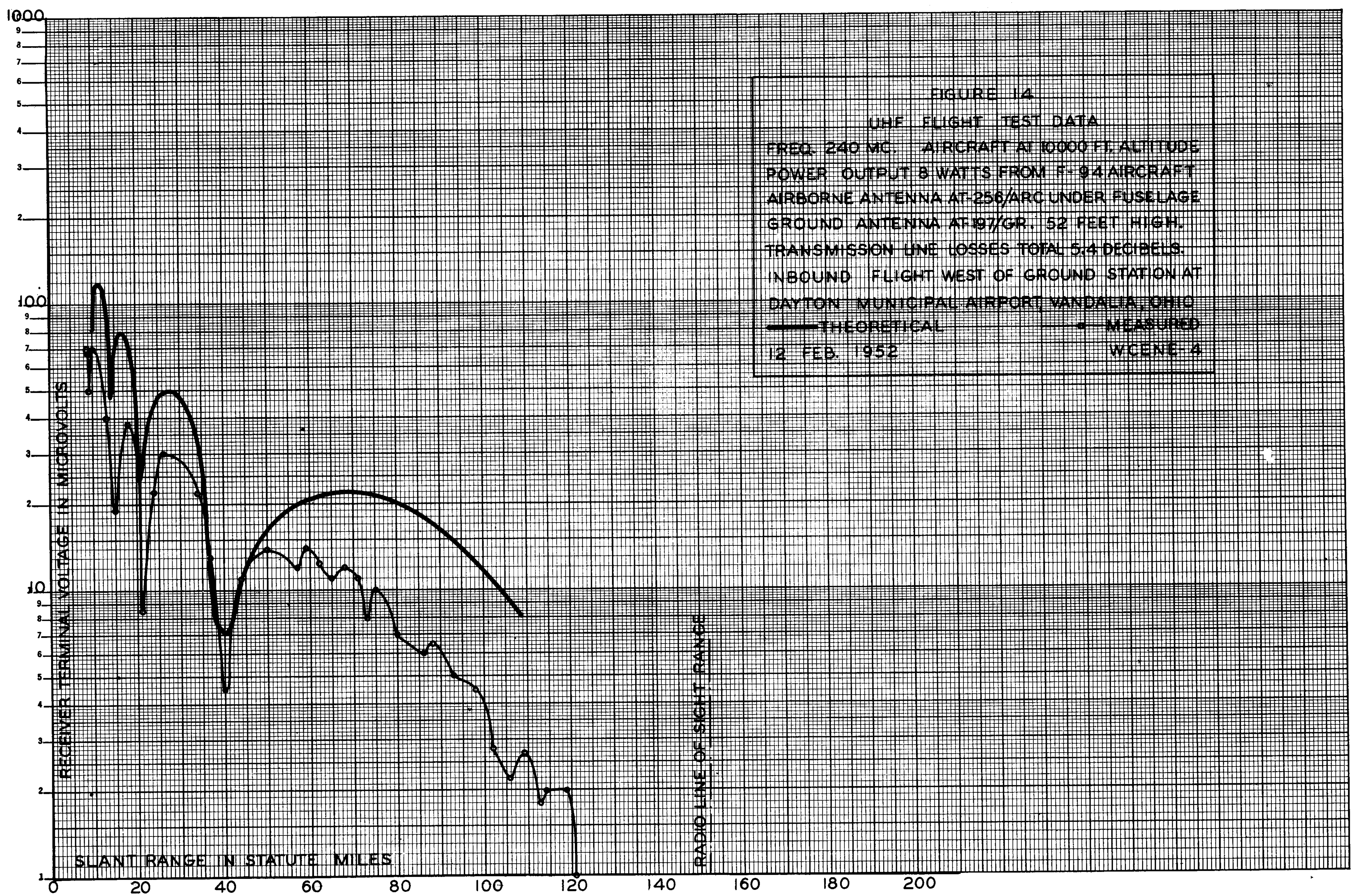


FIGURE 14
UHF FLIGHT TEST DATA
FREQ. 240 MC. AIRCRAFT AT 10000 FT. ALTITUDE
POWER OUTPUT 8 WATTS FROM F-94 AIRCRAFT
AIRBORNE ANTENNA AT-256/ARC UNDER FUSELAGE
GROUND ANTENNA AT-197/GR. 52 FEET HIGH.
TRANSMISSION LINE LOSSES TOTAL 5.4 DECIBELS.
INBOUND FLIGHT WEST OF GROUND STATION AT
DAYTON MUNICIPAL AIRPORT, VANDALIA, OHIO
THEORETICAL
MEASURED
12 FEB. 1952
WCENE-4
RECEIVER TERMINAL VOLTAGE IN MICROVOLTS
SLANT RANGE IN STATUTE MILES
RADIO LINE OF SIGHT RANGE
1000
100
10
1
0
20
40
60
80
100
120
140
160
180
200

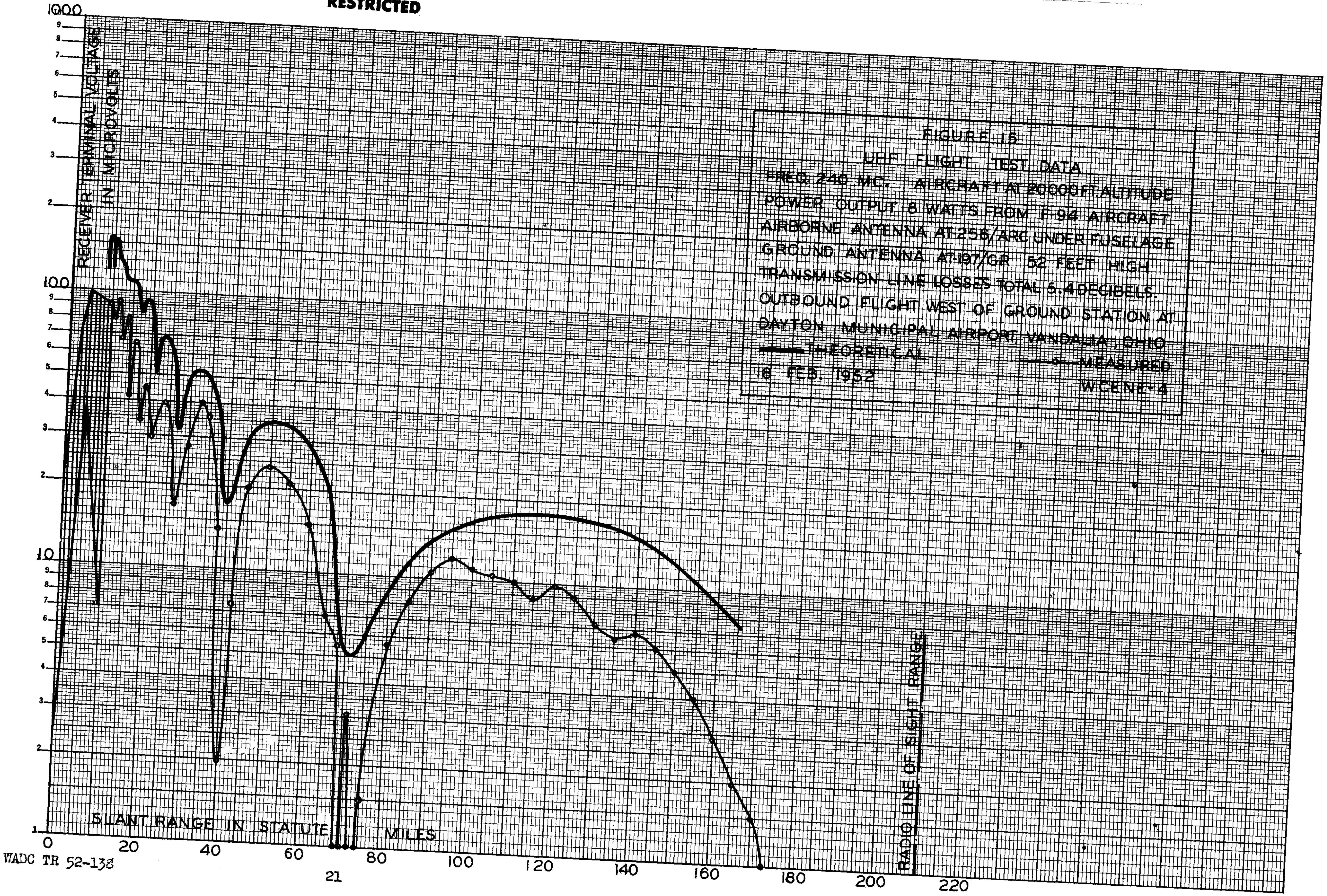


FIGURE 15
UHF FLIGHT TEST DATA
FREQ. 240 MC. AIRCRAFT AT 20000 FT. ALTITUDE
POWER OUTPUT 8 WATTS FROM F-94 AIRCRAFT
AIRBORNE ANTENNA AT-256/ARC UNDER FUSELAGE
GROUND ANTENNA AT-197/GR 52 FEET HIGH
TRANSMISSION LINE LOSSES TOTAL 5.4 DECIBELS.
OUTBOUND FLIGHT WEST OF GROUND STATION AT
DAYTON MUNICIPAL AIRPORT, VANDALIA, OHIO
THEORETICAL
MEASURED
18 FEB. 1952
WCENE-4
RECEIVER TERMINAL VOLTAGE IN MICROVOLTS
SLANT RANGE IN STATUTE MILES
RADIO LINE OF SIGHT RANGE
1000
100
10
1
0
20
40
60
80
100
120
140
160
180
200
220

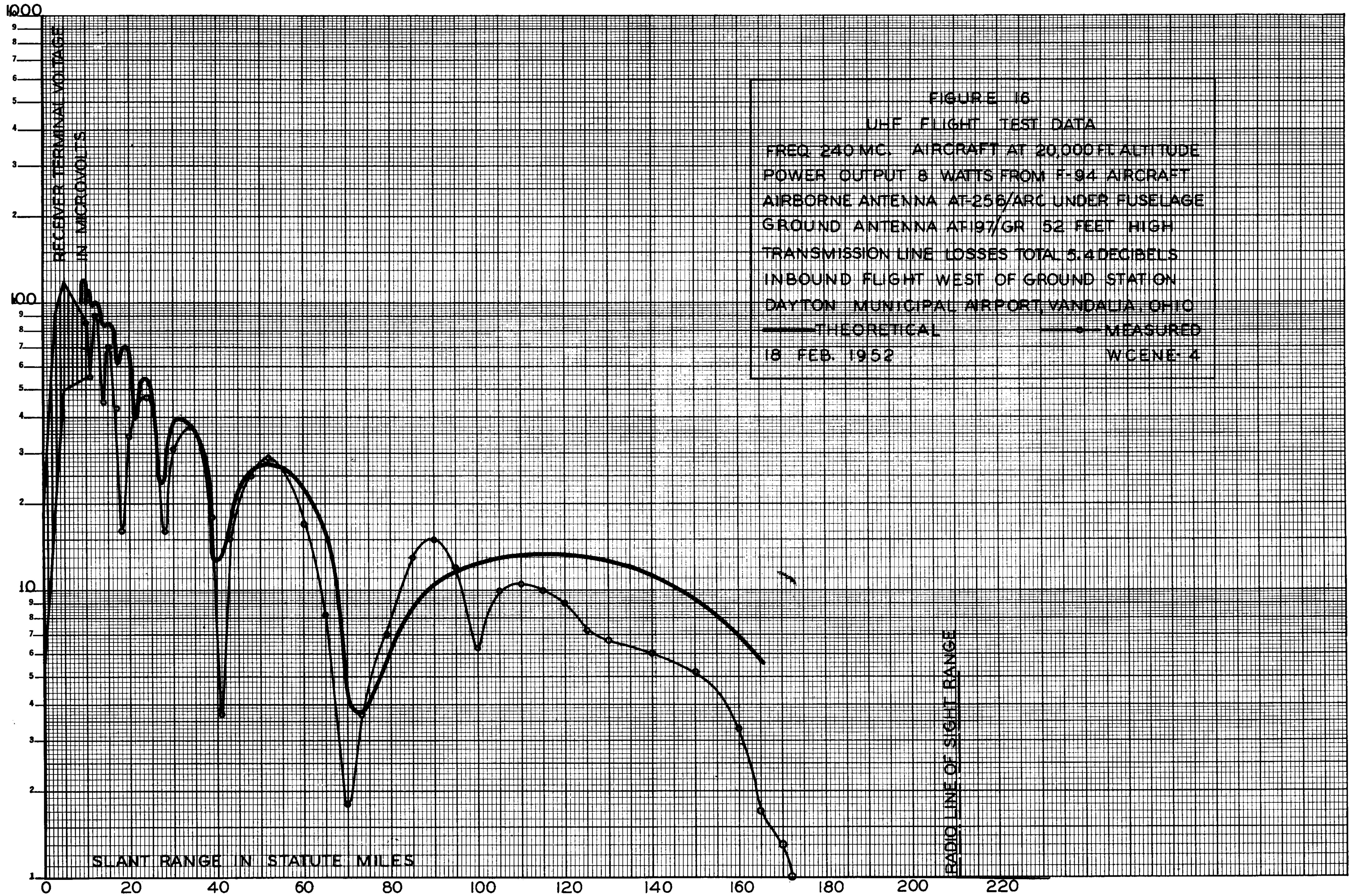


FIGURE 16
UHF FLIGHT TEST DATA
FREQ. 240 MC. AIRCRAFT AT 20,000 FT. ALTITUDE
POWER OUTPUT 8 WATTS FROM F-94 AIRCRAFT
AIRBORNE ANTENNA AT-256/ARC UNDER FUSELAGE
GROUND ANTENNA AT-197/GR 52 FEET HIGH
TRANSMISSION LINE LOSSES TOTAL 5.4 DECIBELS
INBOUND FLIGHT WEST OF GROUND STATION
DAYTON MUNICIPAL AIRPORT, VANDALIA, OHIO
THEORETICAL
MEASURED
18 FEB. 1952
WCENE-4
RECEIVER TERMINAL VOLTAGE IN MICROVOLTS
SLANT RANGE IN STATUTE MILES
RADIO LINE OF SIGHT RANGE
1000
100
10
0
20
40
60
80
100
120
140
160
180
200
220

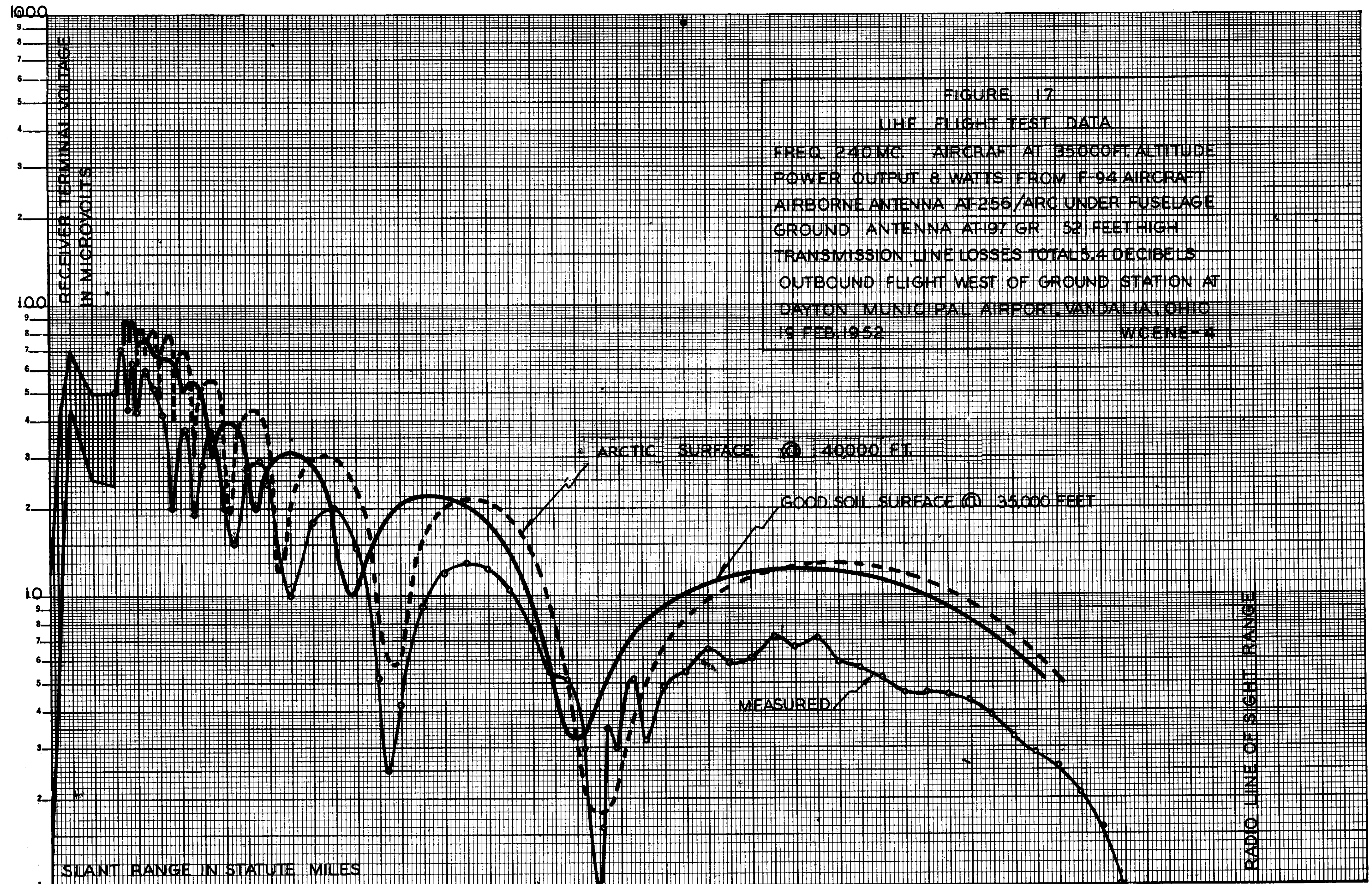


FIGURE 17
UHF FLIGHT TEST DATA
FREQ. 240 MC. AIRCRAFT AT 35000FT. ALTITUDE
POWER OUTPUT 8 WATTS FROM F-94 AIRCRAFT
AIRBORNE ANTENNA AT-256/ARC UNDER FUSELAGE
GROUND ANTENNA AT-97 GR 52 FEET HIGH
TRANSMISSION LINE LOSSES TOTAL 5.4 DECIBELS
OUTBOUND FLIGHT WEST OF GROUND STATION AT
DAYTON MUNICIPAL AIRPORT, VANDALIA, OHIO
19 FEB. 1952 WCENE-4
RECEIVER TERMINAL VOLTAGE IN MICROVOLTS
ARCTIC SURFACE @ 40000 FT.
GOOD SOIL SURFACE @ 35,000 FEET
MEASURED
RADIO LINE OF SIGHT RANGE
SLANT RANGE IN STATUTE MILES
1000
100
10
1
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300

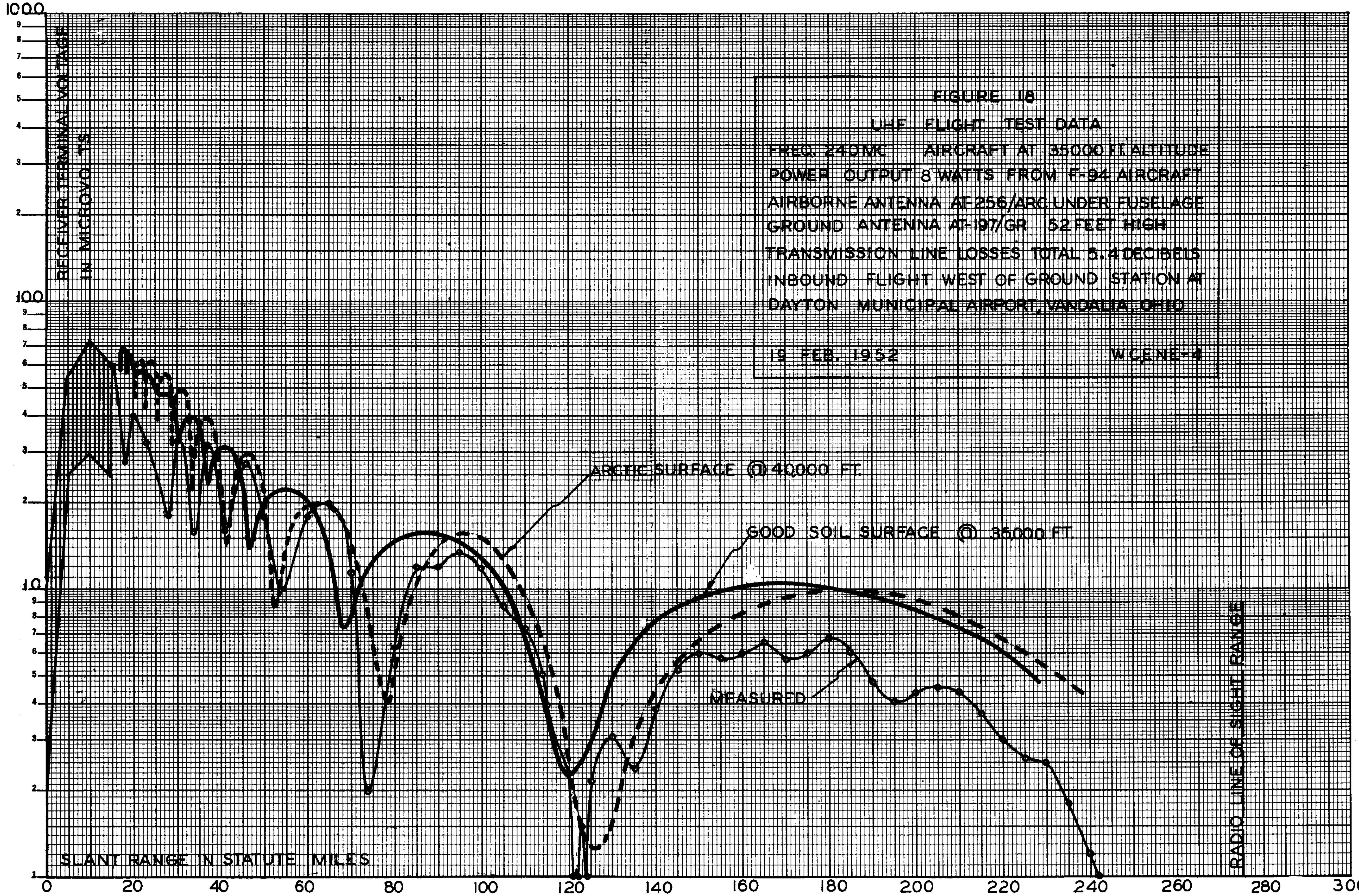
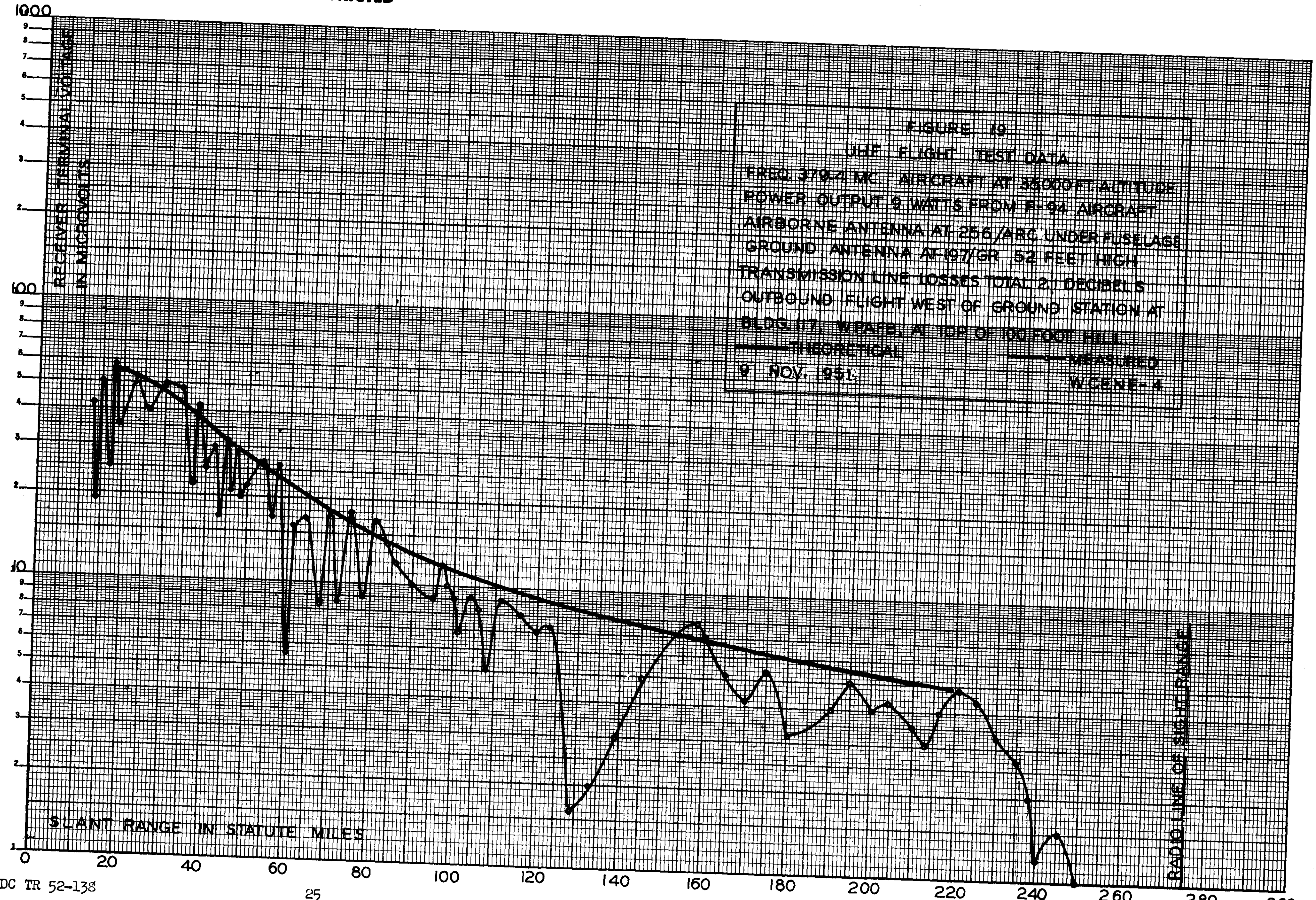


FIGURE 18
UHF FLIGHT TEST DATA
FREQ. 240 MC AIRCRAFT AT 35000 FT. ALTITUDE
POWER OUTPUT 8 WATTS FROM F-94 AIRCRAFT
AIRBORNE ANTENNA AT-256/ARC UNDER FUSELAGE
GROUND ANTENNA AT-197/GR 52 FEET HIGH
TRANSMISSION LINE LOSSES TOTAL 5.4 DECIBELS
INBOUND FLIGHT WEST OF GROUND STATION AT
DAYTON MUNICIPAL AIRPORT, VANDALIA, OHIO
19 FEB. 1952
WCENE-4
RECEIVER TERMINAL VOLTAGE
IN MICROVOLTS
ARCTIC SURFACE @ 40,000 FT.
GOOD SOIL SURFACE @ 36,000 FT.
MEASURED
RADIO LINE OF SIGHT RANGE
SLANT RANGE IN STATUTE MILES
1000
100
10
1
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300


RECEIVER TERMINAL VOLTAGE IN MICROVOLTS
1000
100
10
1
FIGURE 19
UHF FLIGHT TEST DATA
FREQ. 379.4 MC. AIRCRAFT AT 35000 FT. ALTITUDE
POWER OUTPUT 9 WATTS FROM F-94 AIRCRAFT
AIRBORNE ANTENNA AT-256/ARC UNDER FUSELAGE
GROUND ANTENNA AT-197/GR 52 FEET HIGH
TRANSMISSION LINE LOSSES TOTAL 2.1 DECIBELS
OUTBOUND FLIGHT WEST OF GROUND STATION AT
BLDG. 117, WPAFB, AT TOP OF 100 FOOT HILL.
THEORETICAL
MEASURED
9 NOV. 951
WCENE-4
RADIO LINE OF SIGHT RANGE
SLANT RANGE IN STATUTE MILES
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300

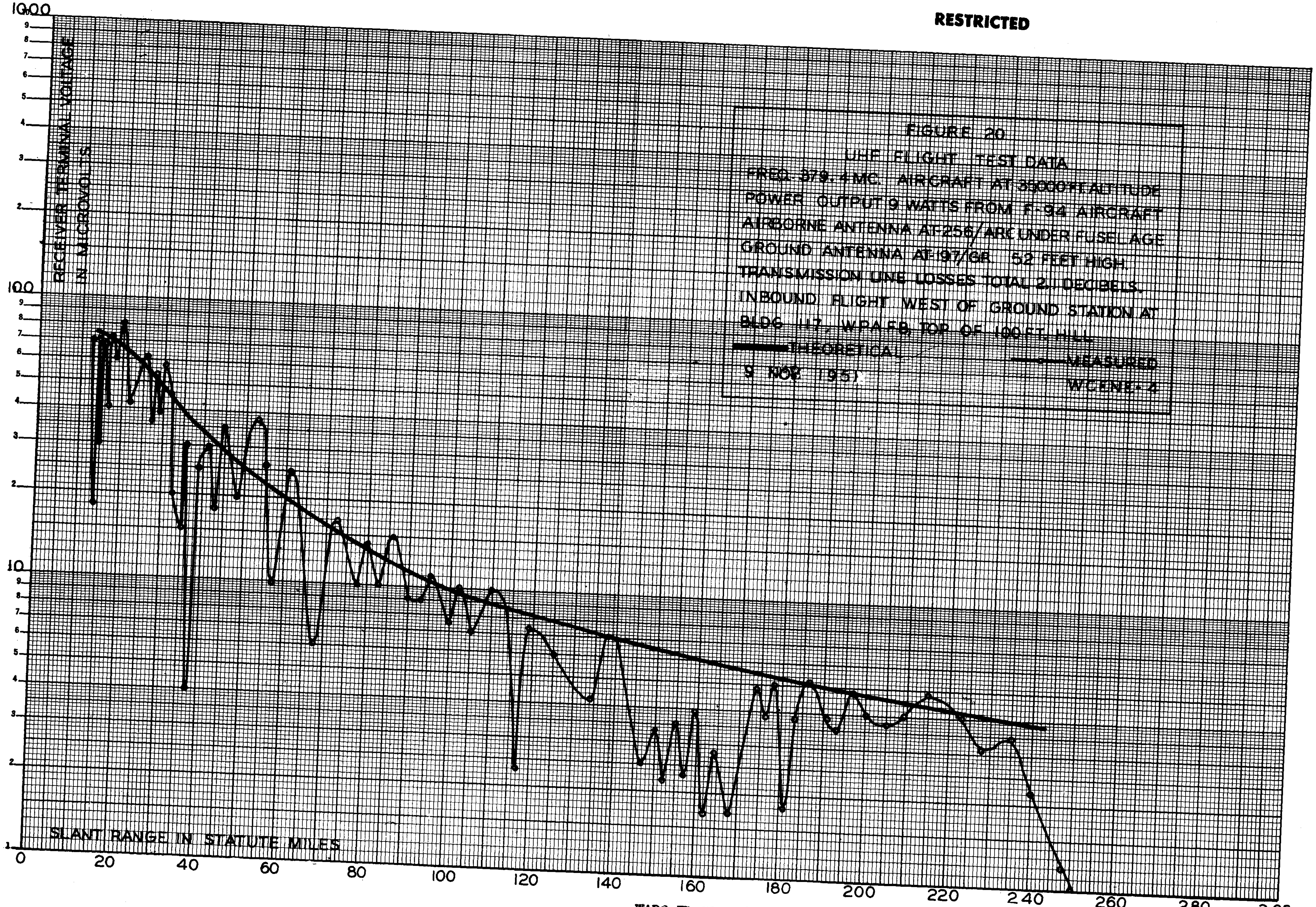


FIGURE 20
UHF FLIGHT TEST DATA
FREQ. 379.4 MC. AIRCRAFT AT 35000 FT ALTITUDE
POWER OUTPUT 9 WATTS FROM F-94 AIRCRAFT
AIRBORNE ANTENNA AT-256/ARC UNDER FUSELAGE
GROUND ANTENNA AT-197/GR 52 FEET HIGH
TRANSMISSION LINE LOSSES TOTAL 2.1 DECIBELS.
INBOUND FLIGHT WEST OF GROUND STATION AT
BLDG 117, W.P.A.F.B. TOP OF 100 FT. HILL
THEORETICAL
MEASURED
9 NOV 1951
WCENE-4
RECEIVER TERMINAL VOLTAGE IN MICROVOLTS
SLANT RANGE IN STATUTE MILES
1000
100
10
1
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300

9

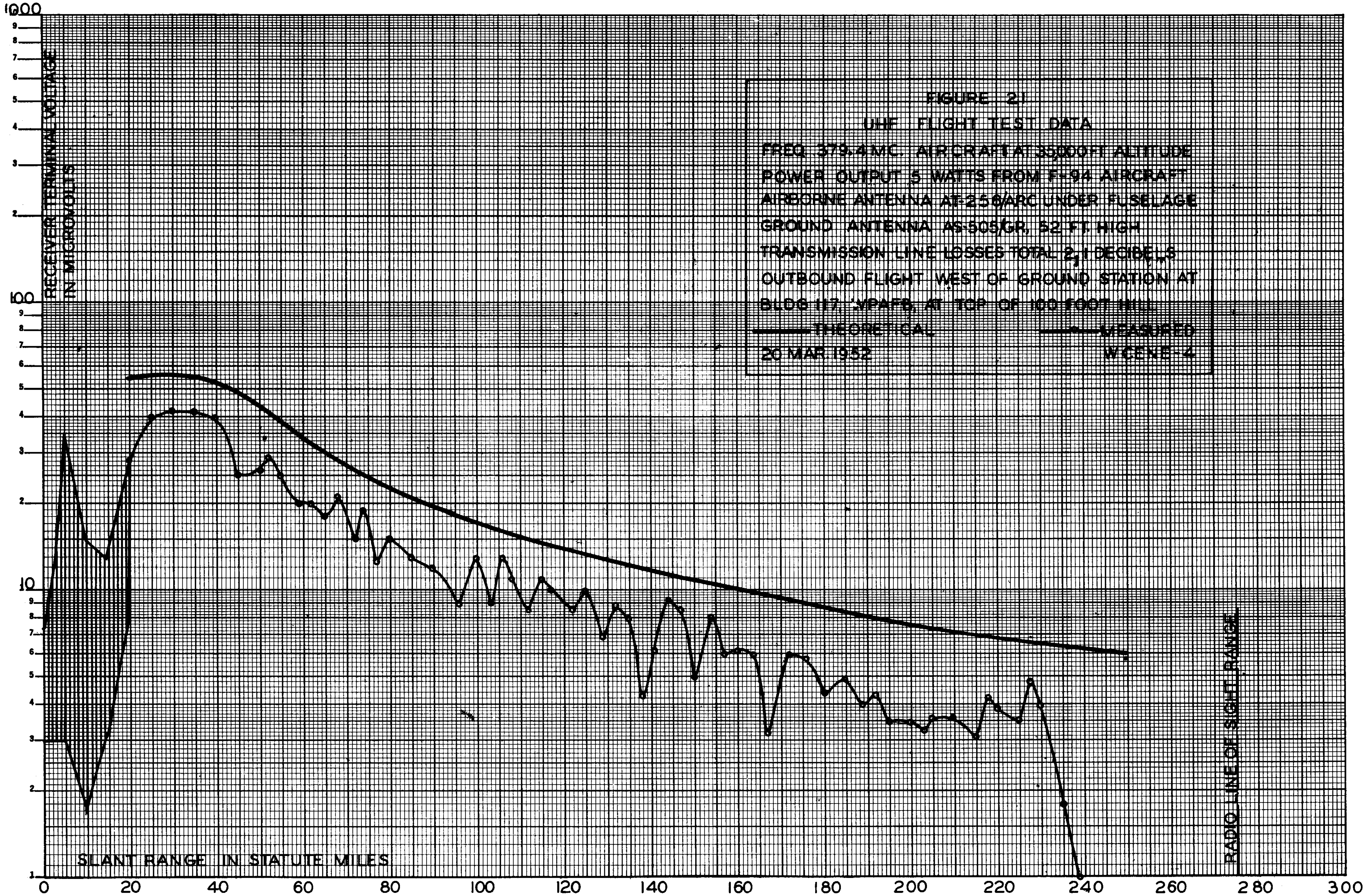


FIGURE 21
UHF FLIGHT TEST DATA
FREQ. 379.4 MC. AIRCRAFT AT 35,000 FT ALTITUDE
POWER OUTPUT 5 WATTS FROM F-94 AIRCRAFT
AIRBORNE ANTENNA AT-256/ARC UNDER FUSELAGE
GROUND ANTENNA AS-505/GR, 52 FT HIGH
TRANSMISSION LINE LOSSES TOTAL 2.1 DECIBELS
OUTBOUND FLIGHT WEST OF GROUND STATION AT
BLDG 117, WPAFB, AT TOP OF 100 FOOT HILL
THEORETICAL
MEASURED
20 MAR 1952
WCENE-4
RECEIVER TERMINAL VOLTAGE IN MICROVOLTS
SLANT RANGE IN STATUTE MILES
RADIO LINE OF SIGHT RANGE
1000
100
10
1
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300

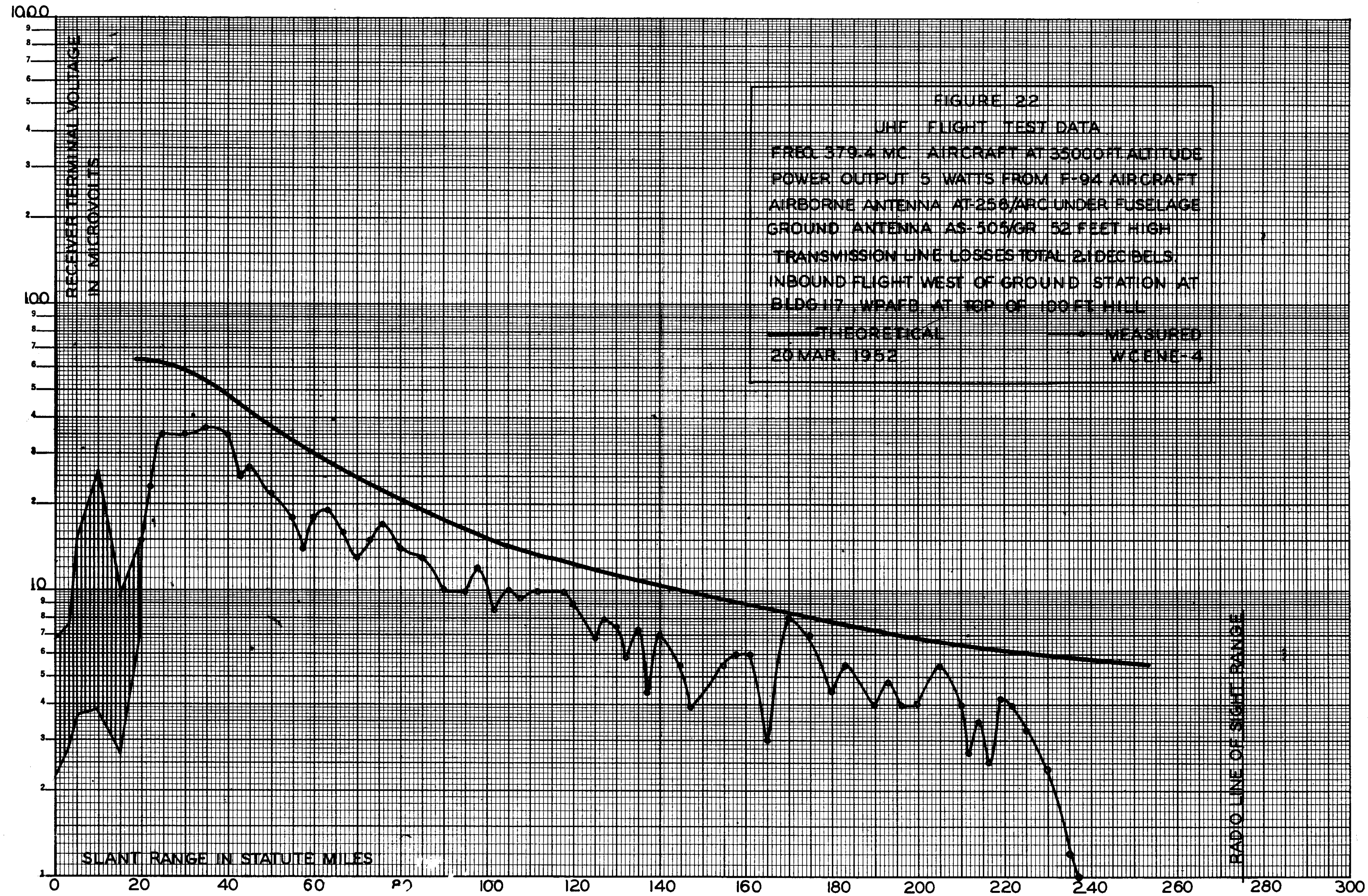


FIGURE 22
UHF FLIGHT TEST DATA
FREQ. 379.4 MC. AIRCRAFT AT 35000FT ALTITUDE
POWER OUTPUT 5 WATTS FROM F-94 AIRCRAFT
AIRBORNE ANTENNA AT-256/ARC UNDER FUSELAGE
GROUND ANTENNA AS-505/GR 52 FEET HIGH
TRANSMISSION LINE LOSSES TOTAL 2.1 DECIBELS.
INBOUND FLIGHT WEST OF GROUND STATION AT
BLDG 117, WPAFB, AT TOP OF 100 FT HILL
THEORETICAL
MEASURED
20 MAR. 1952
WCENE-4
RECEIVER TERMINAL VOLTAGE IN MICROVOLTS
SLANT RANGE IN STATUTE MILES
RADIO LINE OF SIGHT RANGE
1000
100
10
1
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300

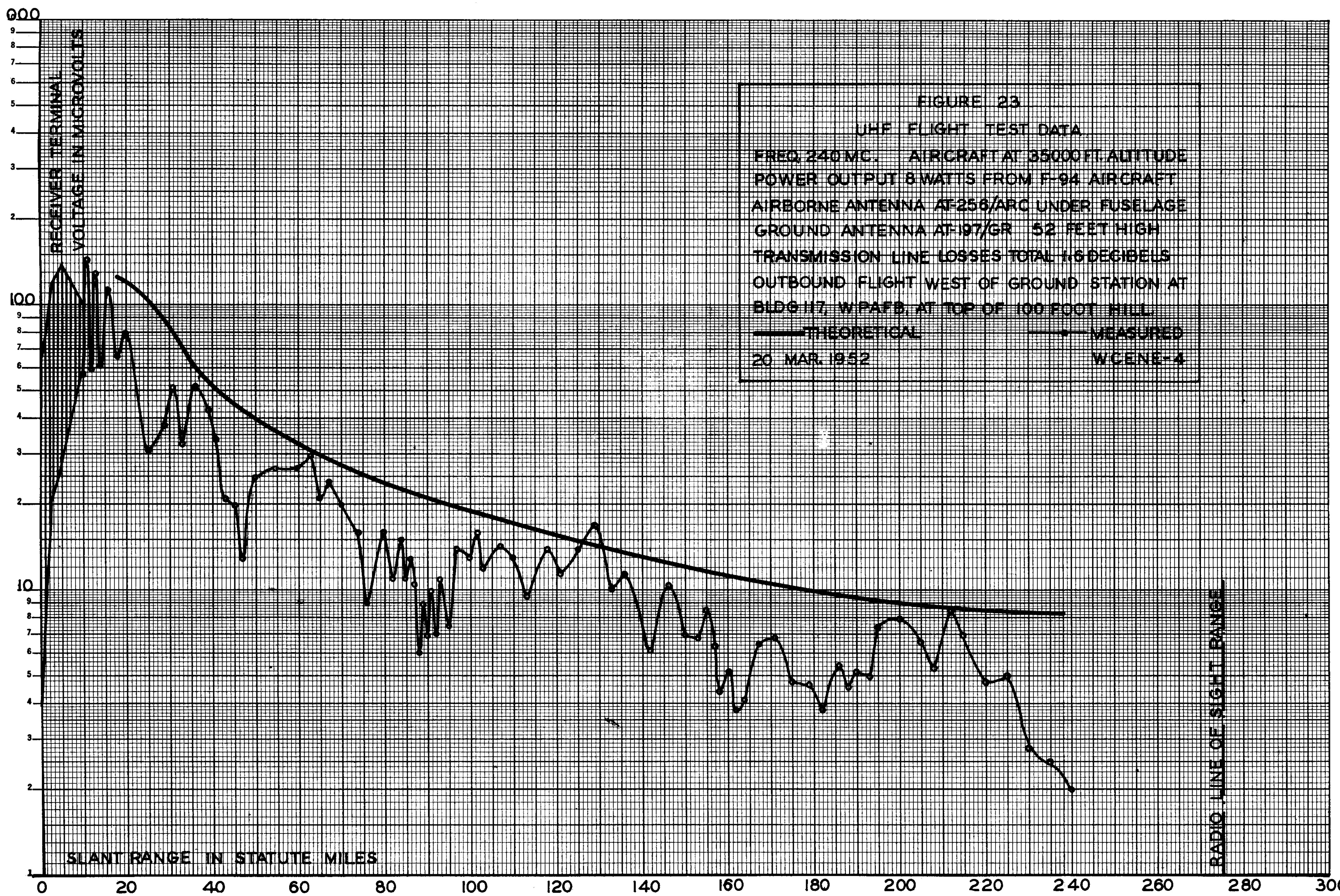


FIGURE 23
UHF FLIGHT TEST DATA
FREQ. 240 MC. AIRCRAFT AT 35000 FT. ALTITUDE
POWER OUTPUT 8 WATTS FROM F-94 AIRCRAFT
AIRBORNE ANTENNA AT-256/ARC UNDER FUSELAGE
GROUND ANTENNA AT-197/GR 52 FEET HIGH
TRANSMISSION LINE LOSSES TOTAL 1.6 DECIBELS
OUTBOUND FLIGHT WEST OF GROUND STATION AT
BLDG 117, W.P.A.F.B. AT TOP OF 100 FOOT HILL
THEORETICAL
MEASURED
20 MAR. 1952
WCENE-4
RECEIVER TERMINAL VOLTAGE IN MICROVOLTS
SLANT RANGE IN STATUTE MILES
RADIO LINE OF SIGHT RANGE
1000
100
10
1
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300

2

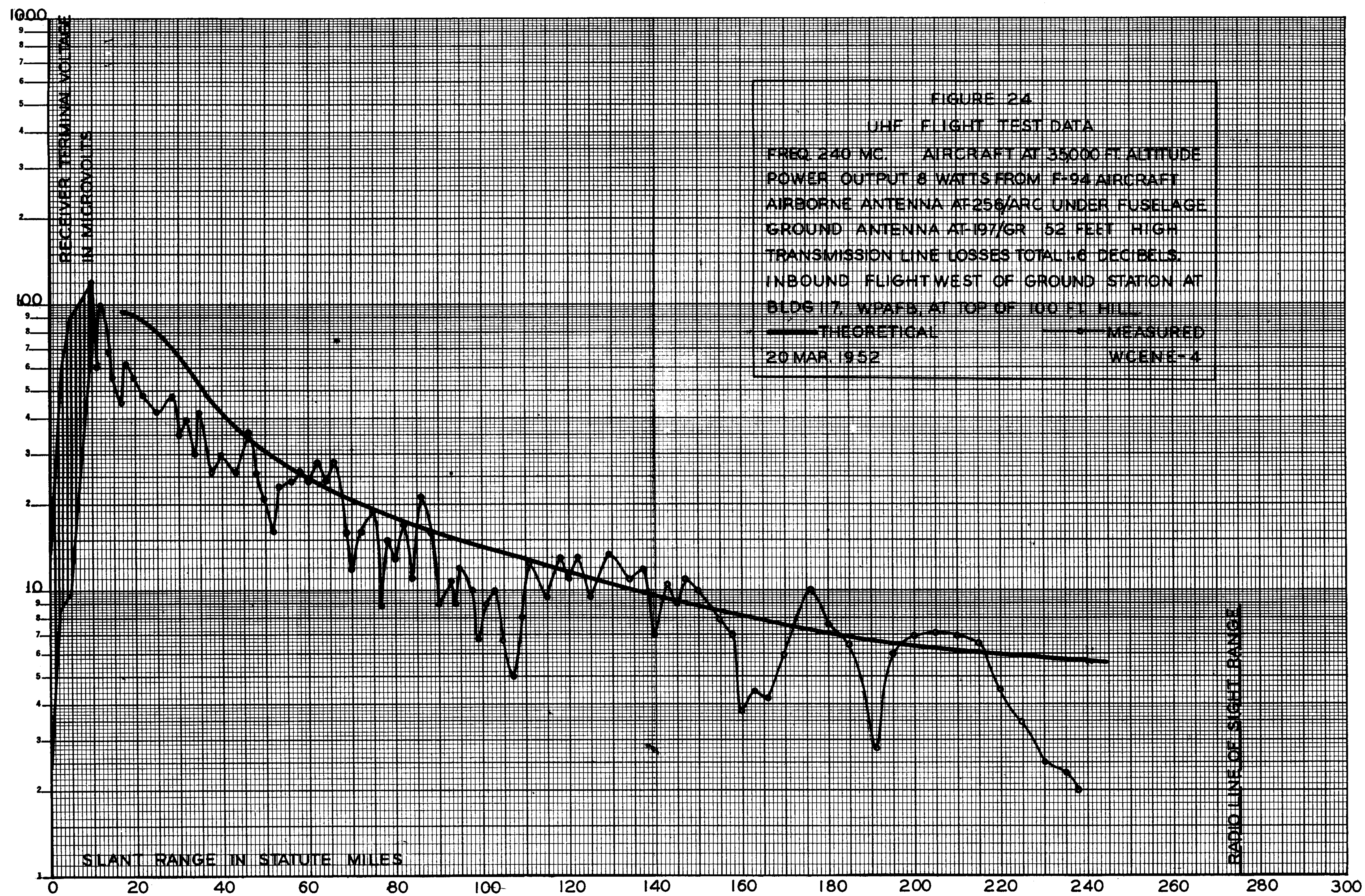


FIGURE 24
UHF FLIGHT TEST DATA
FREQ. 240 MC. AIRCRAFT AT 35000 FT. ALTITUDE
POWER OUTPUT 8 WATTS FROM F-94 AIRCRAFT
AIRBORNE ANTENNA AT 256/ARC UNDER FUSELAGE
GROUND ANTENNA AT-197/GR 52 FEET HIGH
TRANSMISSION LINE LOSSES TOTAL 1.6 DECIBELS.
INBOUND FLIGHT WEST OF GROUND STATION AT
BLDG 17, WPAFB, AT TOP OF 100 FT. HILL.
THEORETICAL
MEASURED
20 MAR. 1952
WCENE-4
RECEIVER TERMINAL VOLTAGE
IN MICROVOLTS
1000
100
10
SLANT RANGE IN STATUTE MILES
RADIO LINE OF SIGHT RANGE
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300

2

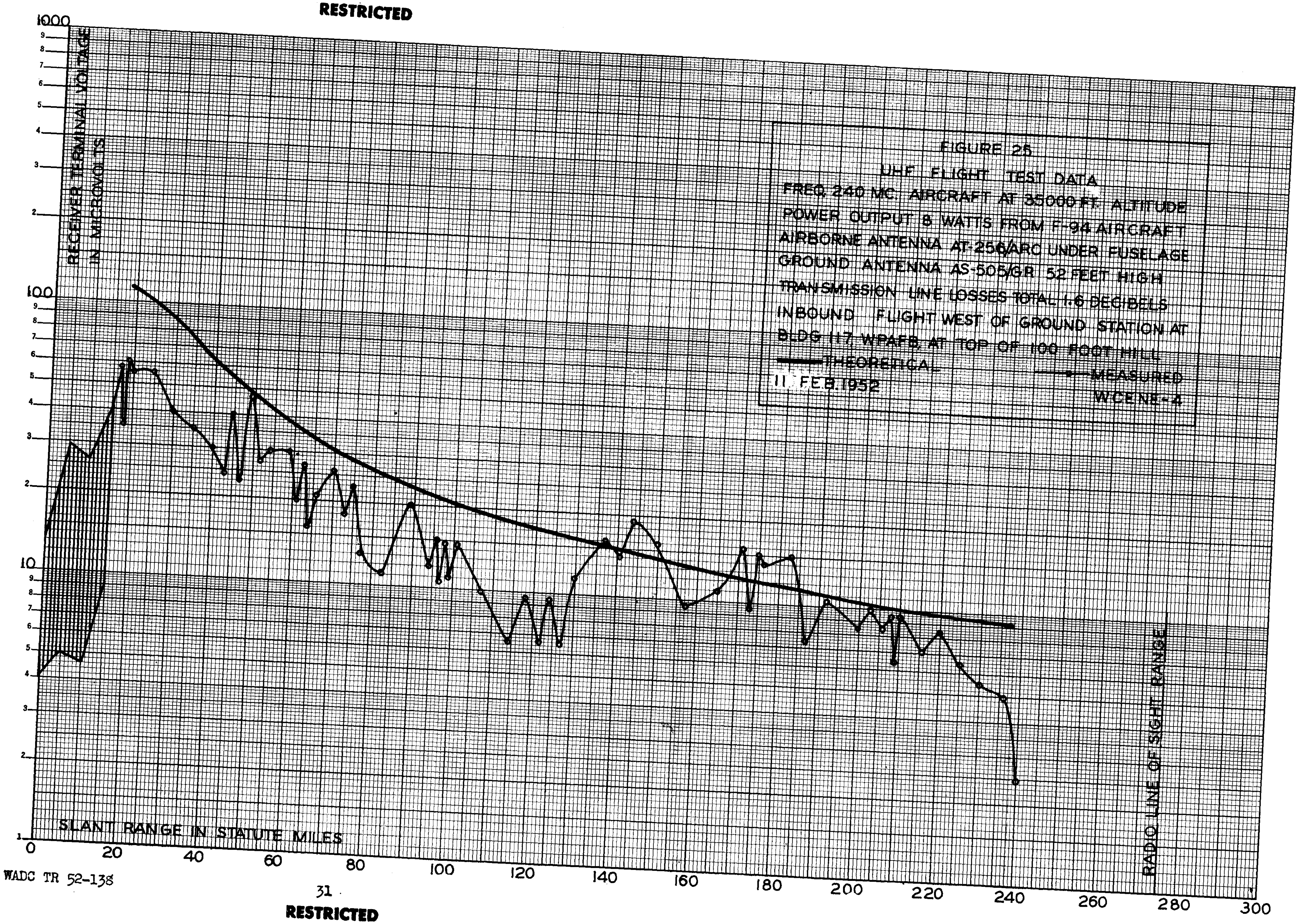


FIGURE 25
UHF FLIGHT TEST DATA
FREQ. 240 MC. AIRCRAFT AT 35000 FT. ALTITUDE
POWER OUTPUT 8 WATTS FROM F-94 AIRCRAFT
AIRBORNE ANTENNA AT-256/ARC UNDER FUSELAGE
GROUND ANTENNA AS-505/GR 52 FEET HIGH
TRANSMISSION LINE LOSSES TOTAL 1.6 DECIBELS
INBOUND FLIGHT WEST OF GROUND STATION AT
BLDG 117 WPAFB AT TOP OF 100 FOOT HILL
THEORETICAL
MEASURED
11 FEB.1952
WCENE-4
RECEIVER TERMINAL VOLTAGE IN MICROVOLTS
SLANT RANGE IN STATUTE MILES
RADIO LINE OF SIGHT RANGE
1000
100
10
1
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300

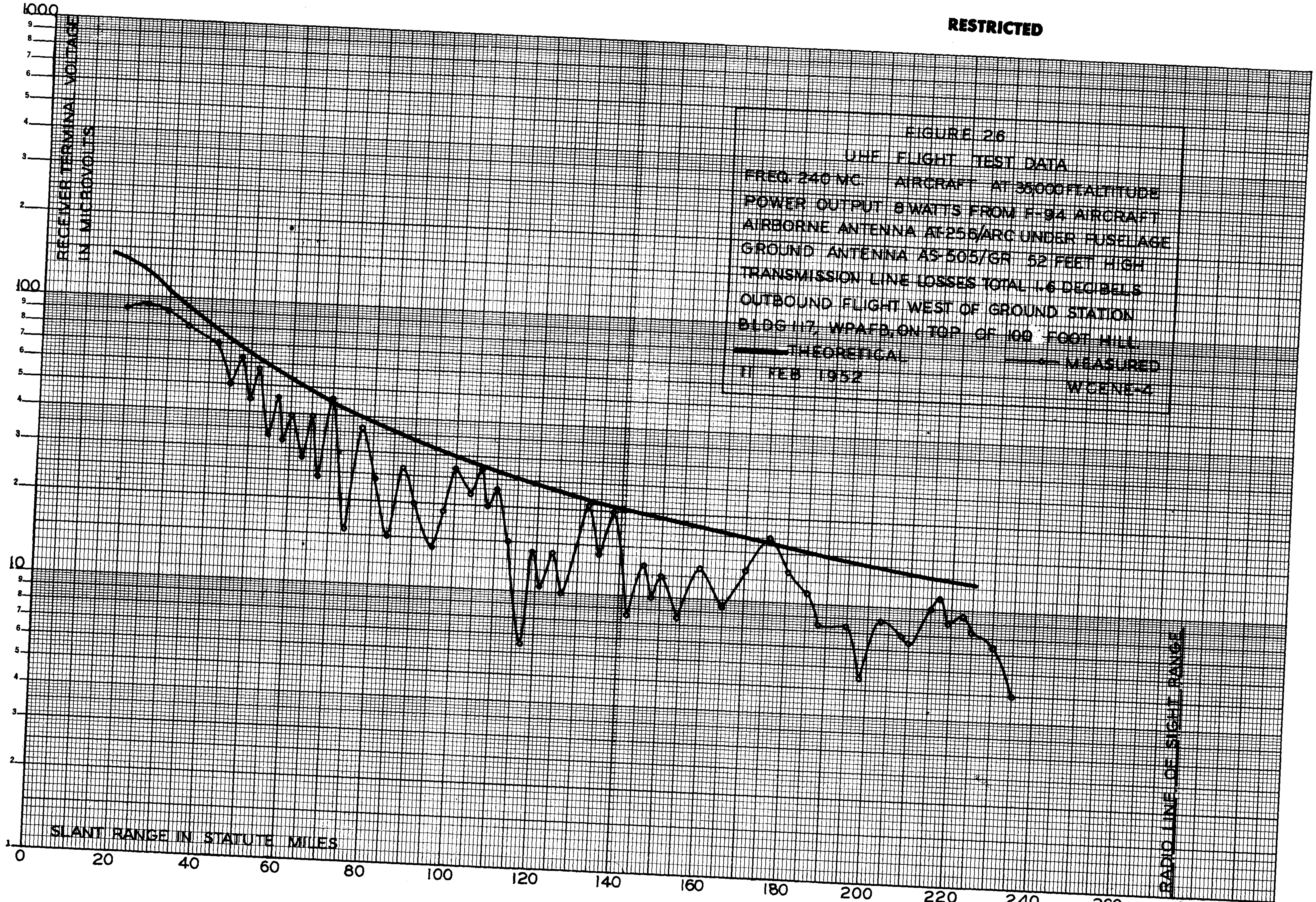


FIGURE 26
UHF FLIGHT TEST DATA
FREQ. 240 MC. AIRCRAFT AT 35000 FT. ALTITUDE
POWER OUTPUT 8 WATTS FROM F-94 AIRCRAFT
AIRBORNE ANTENNA AT-255/ARC UNDER FUSELAGE
GROUND ANTENNA AS-505/GR 52 FEET HIGH
TRANSMISSION LINE LOSSES TOTAL 1.6 DECIBELS
OUTBOUND FLIGHT WEST OF GROUND STATION
BLDG 117, WPAFB, ON TOP OF 100 FOOT HILL.
THEORETICAL
MEASURED
11 FEB 1952
WCENE-4
RECEIVER TERMINAL VOLTAGE IN MICROVOLTS
SLANT RANGE IN STATUTE MILES
RADIO LINE OF SIGHT RANGE
1000
100
10
1
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300

INSTRUCTIONS FOR USING AIL TYPE UHF COVERAGE CHARTS

The charts making up Figures 27 through 42 are representative of the AIL type UHF coverage charts. There are two sets of charts: one, for antenna sites using Antenna AT-197/GR discone 52 feet above the ground, and two, for antenna sites using Antenna Assembly AS-505/GR stacked dipole array 58 feet above the ground. Each set includes charts for four types of surface characteristics and two frequencies. The exact ground system applicable is listed to the right of each chart.

The smooth curves on the left side of the charts are plots of elevation angle of radiation versus aircraft range for various aircraft altitudes. The wavy curve to the right is used to determine signal strength. To find the signal voltage, follow the vertical line from the aircraft range reading to the curve for the aircraft altitude. The horizontal line at this intersection will give the elevation angle of the aircraft. The horizontal distance from the intersection to the wavy line represents the signal voltage in decibels above 3 microvolts using the scale at the top of the chart. Any antenna gain, transmitter power difference, or receiver sensitivity variation must be added or subtracted from this decibel measurement to adjust for such differences.

Example: Figure 27.

Aircraft at 30,000 feet, 100 nautical miles range.
Find elevation angle . . . . <u>2.2 degrees</u>
Find signal strength at aircraft from 100 watt
ground transmitter . . . . . . 12 db above 3 uv. or <u>12 uvolts</u>
Find signal strength at ground station from
10 watt airborne transmitter (10 watts is
10 db below 100 watts) 12 db - 10 db = 2 db
. . . . 2 db above 3 uv. or <u>3.8 uvolts</u>

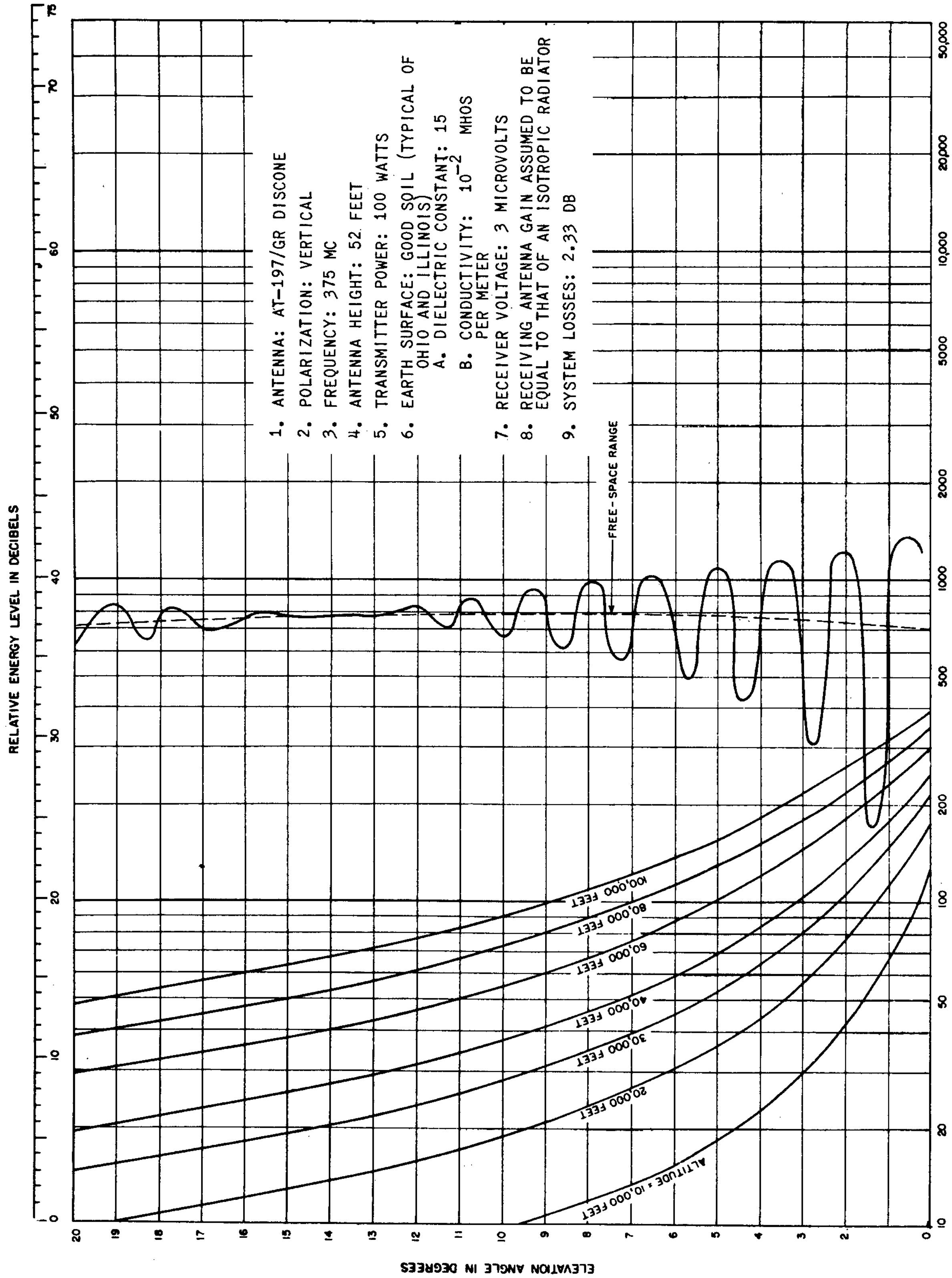


Figure 27. UHF Coverage Chart - Antenna AT-197/GR at 240 mc. Earth Surface: Good Soil

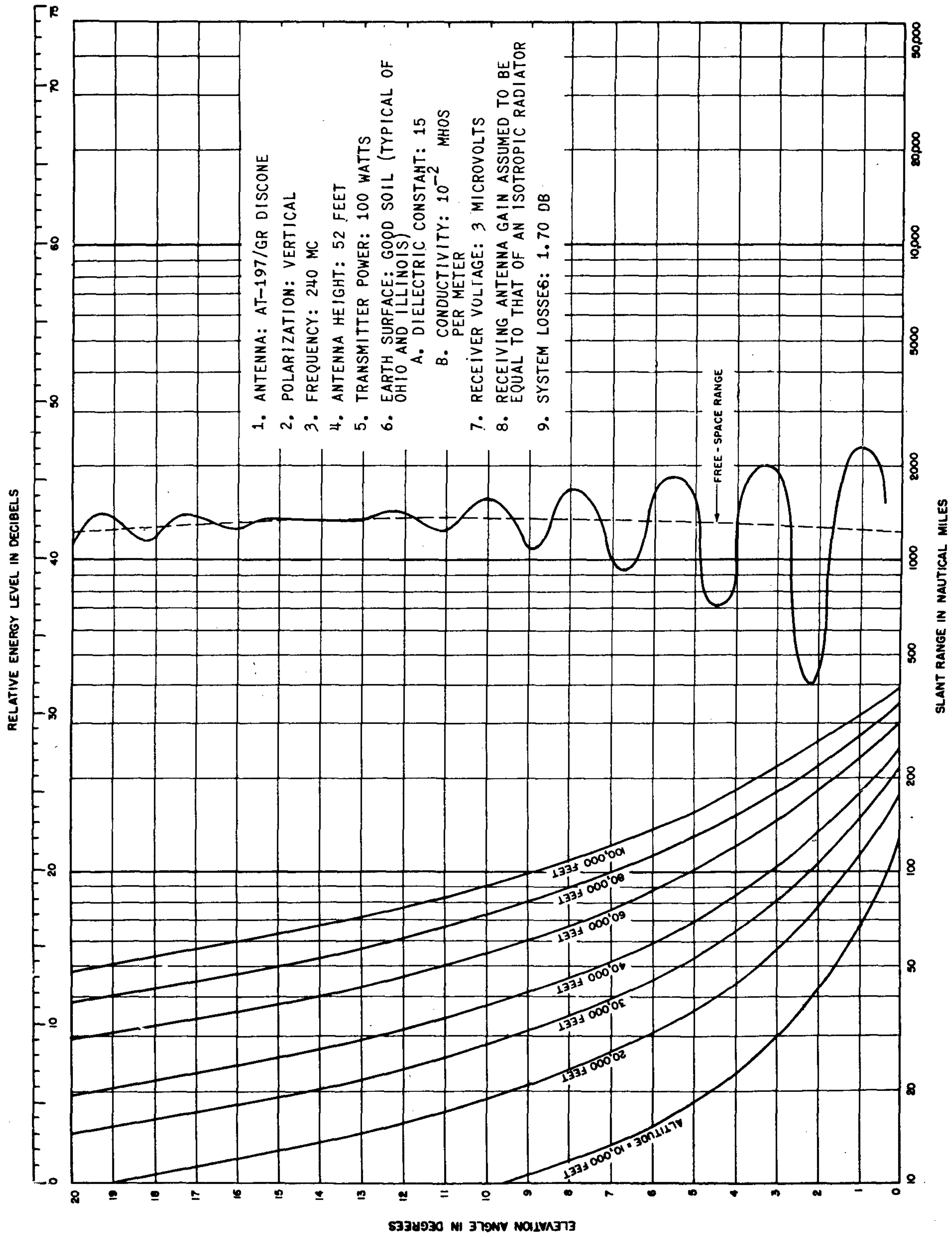


Figure 28. UHF Coverage Chart - Antenna AT-197/GR at 375 mc. Earth Surface: Good Soil

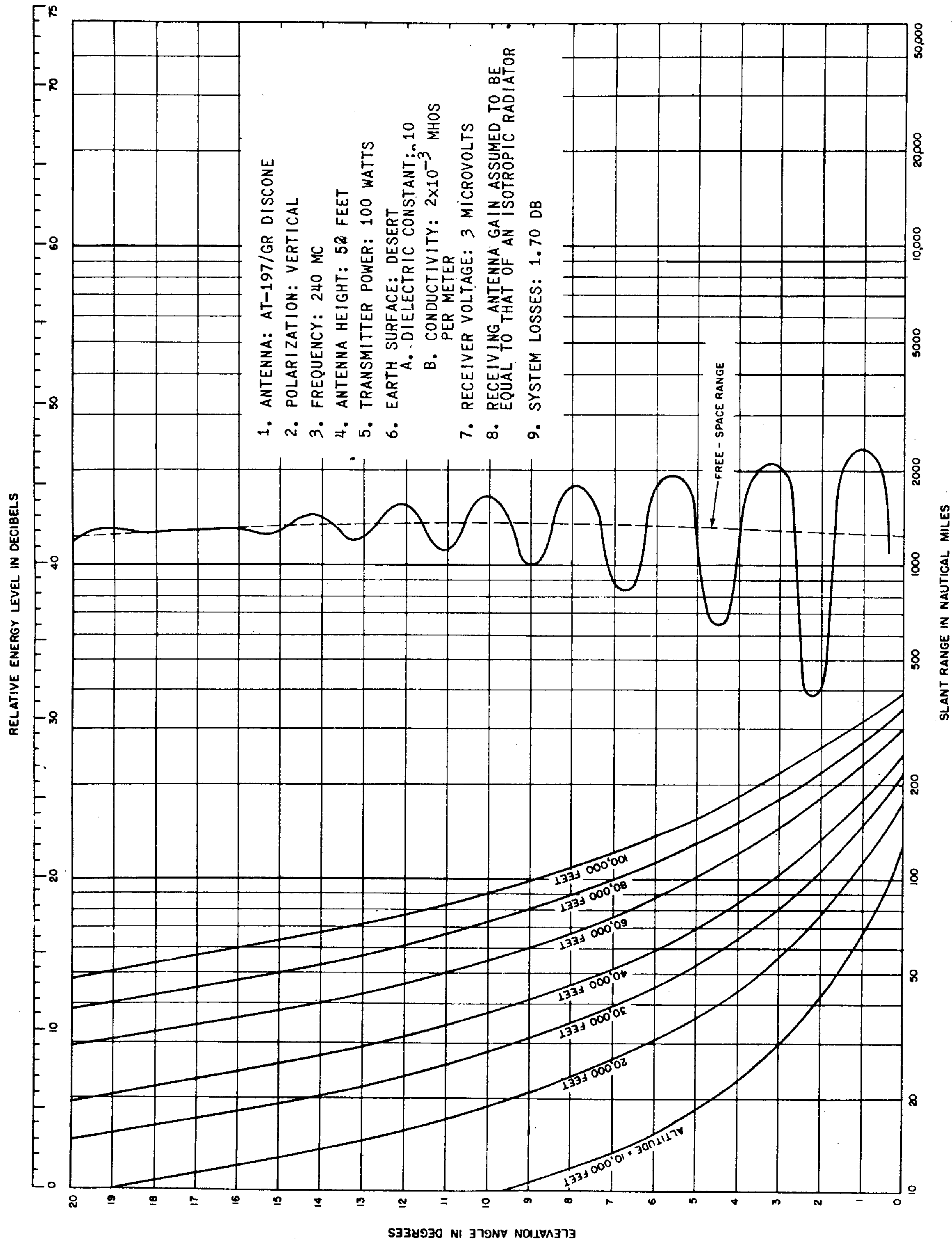


Figure 29. UHF Coverage Chart - Antenna AT-197/GR at 240 mc. Earth Surface: Desert

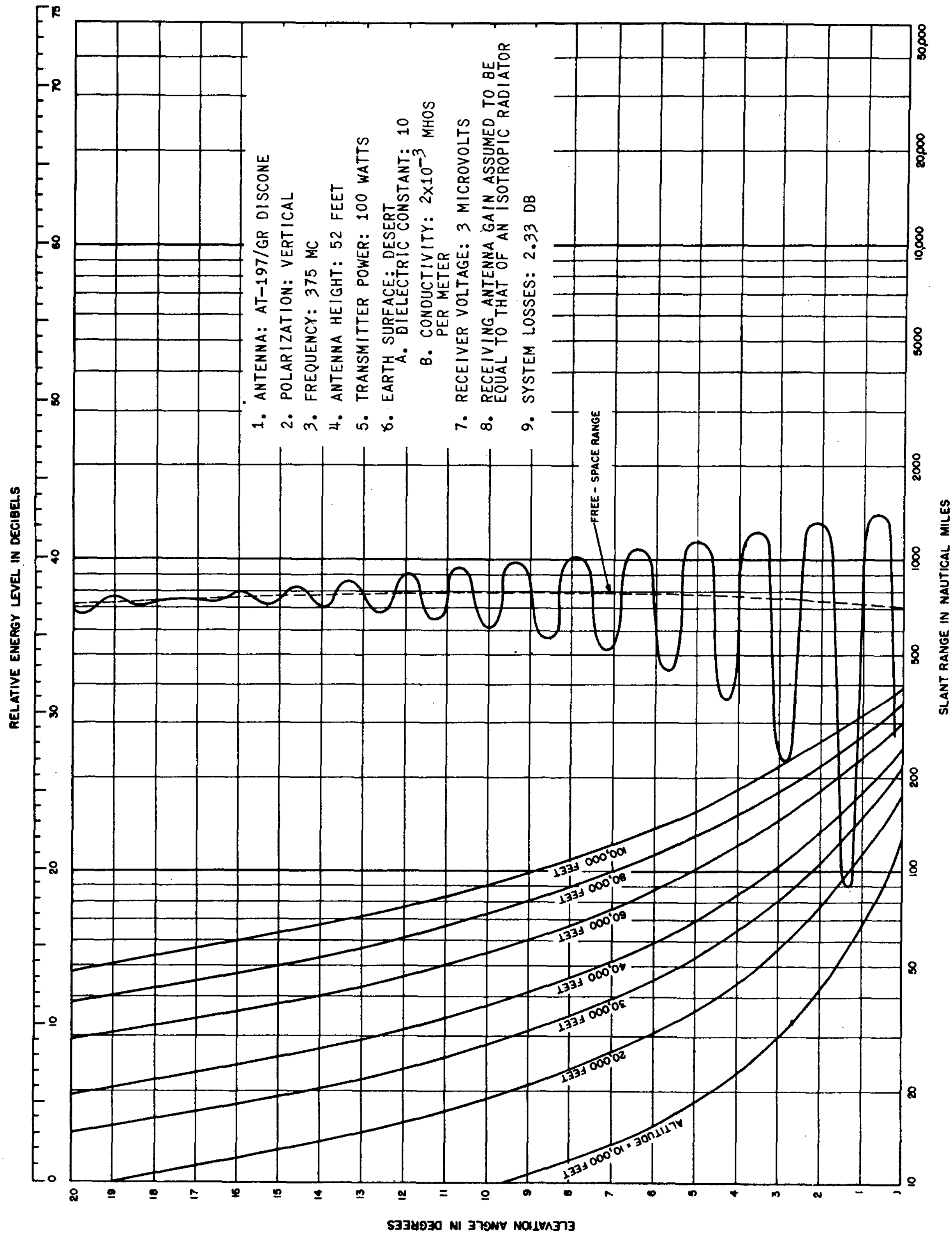


Figure 30. UHF Coverage Chart - Antenna AT-197/GR at 375 mc. Earth Surface: Desert

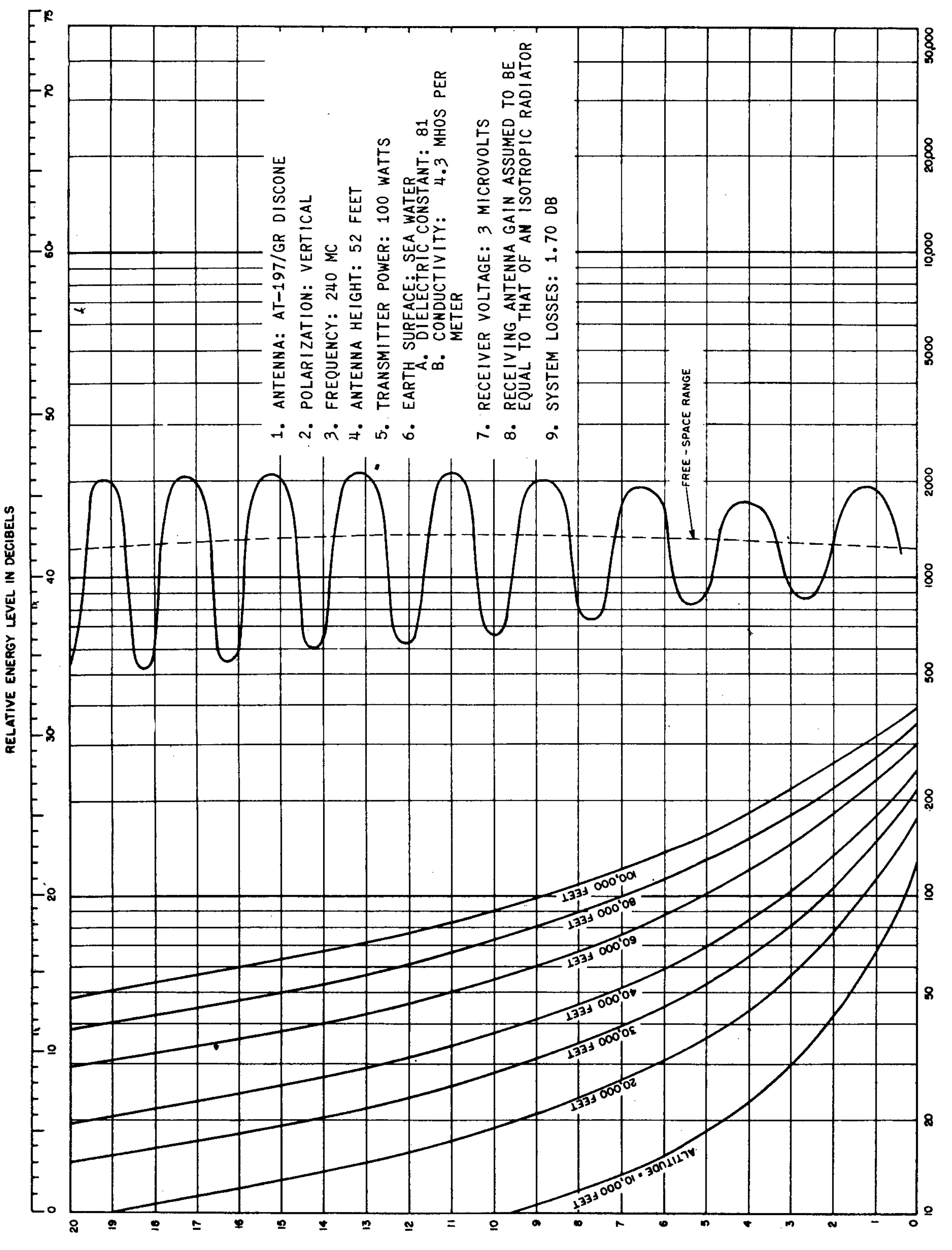


Figure 31. UHF Coverage Chart - Antenna AT-197/GR at 240 mc. Earth Surface: Sea Water

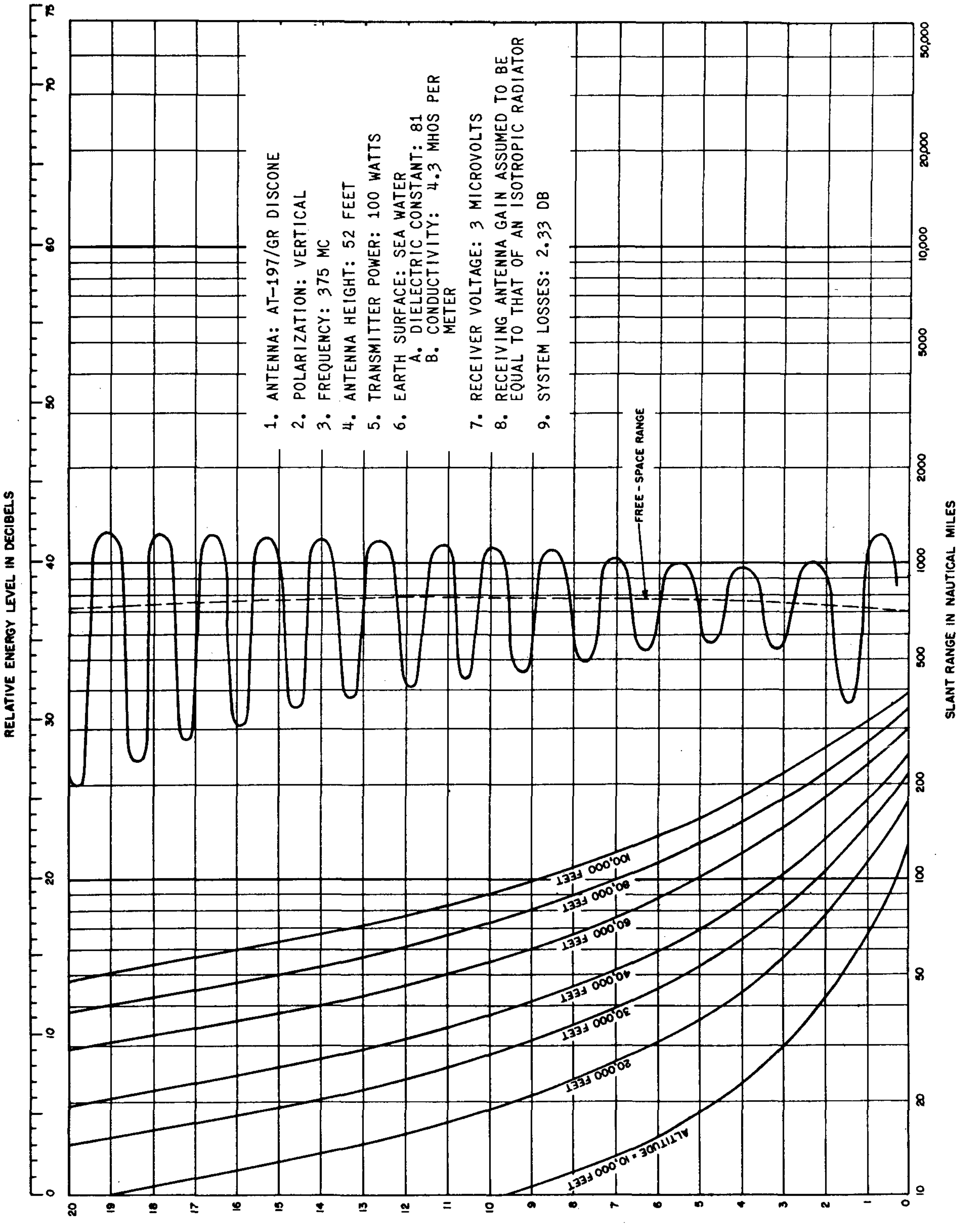


Figure 32. UHF Coverage Chart - Antenna AT-197/GR at 375 mc. Earth Surface: Sea Water

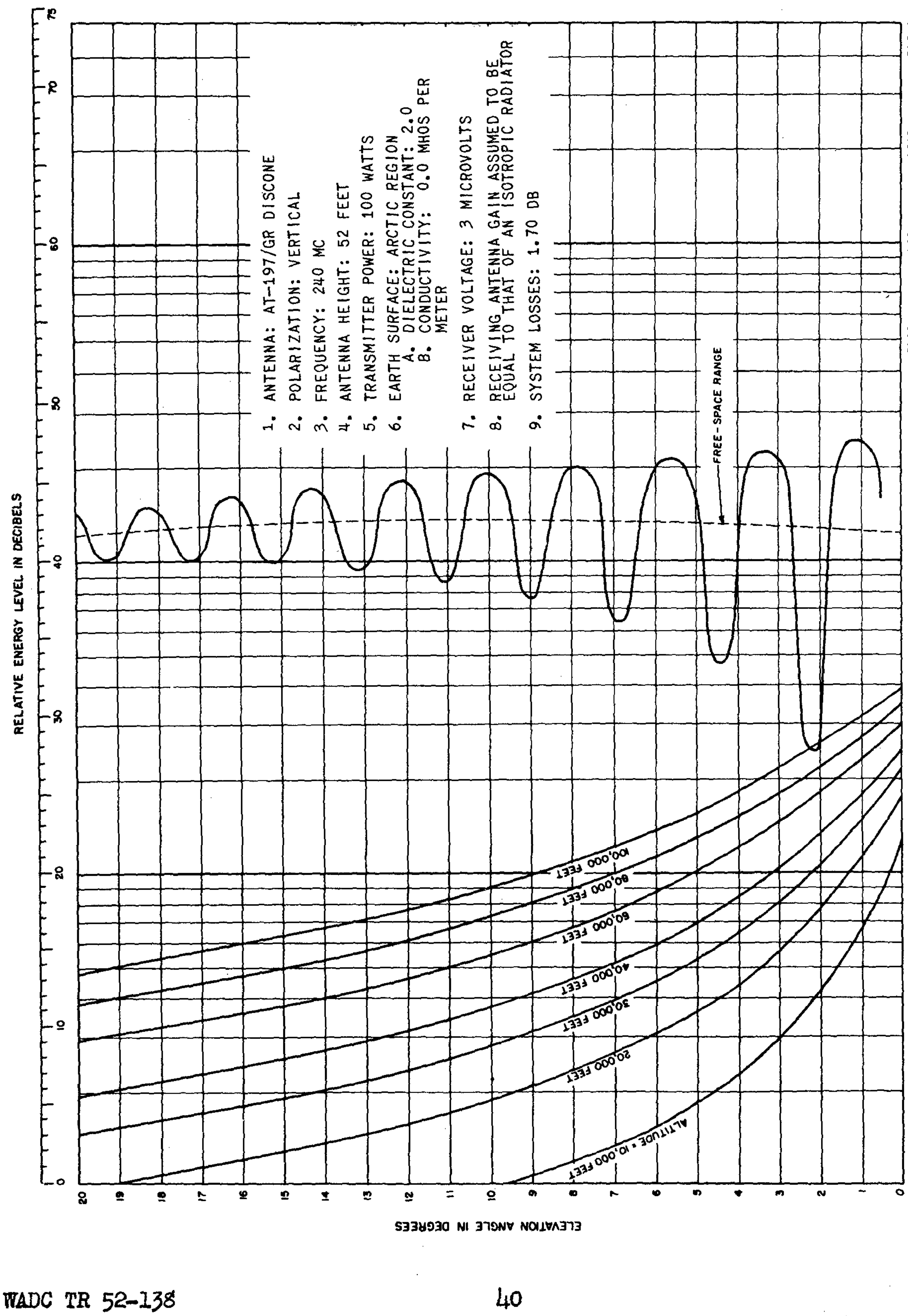


Figure 33. UHF Coverage Chart - Antenna AT-197/GR at 240 mc. Earth Surface: Arctic Region

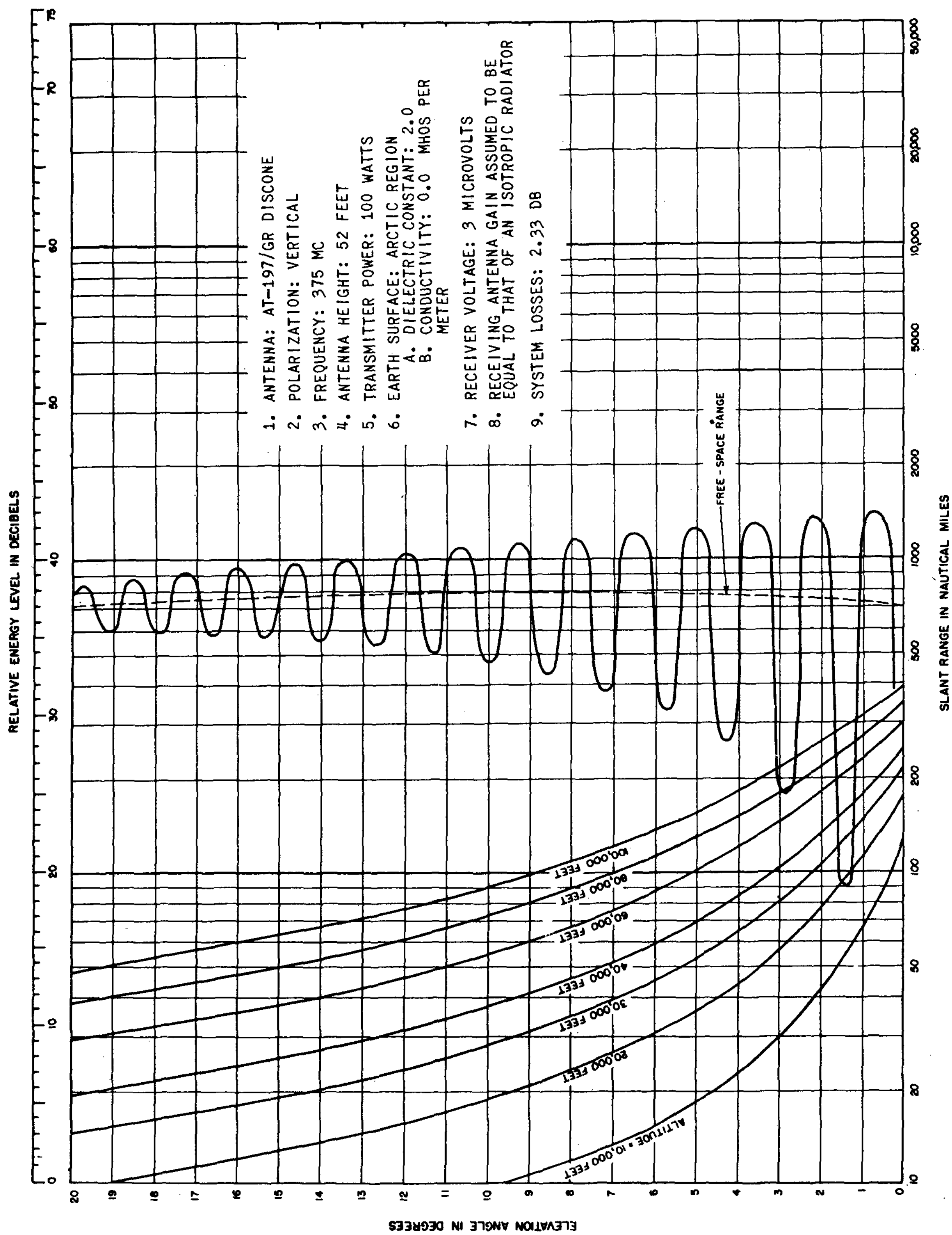


Figure 34. UHF Coverage Chart - Antenna AT-197/GR at 375 mc. Earth Surface: Arctic Region

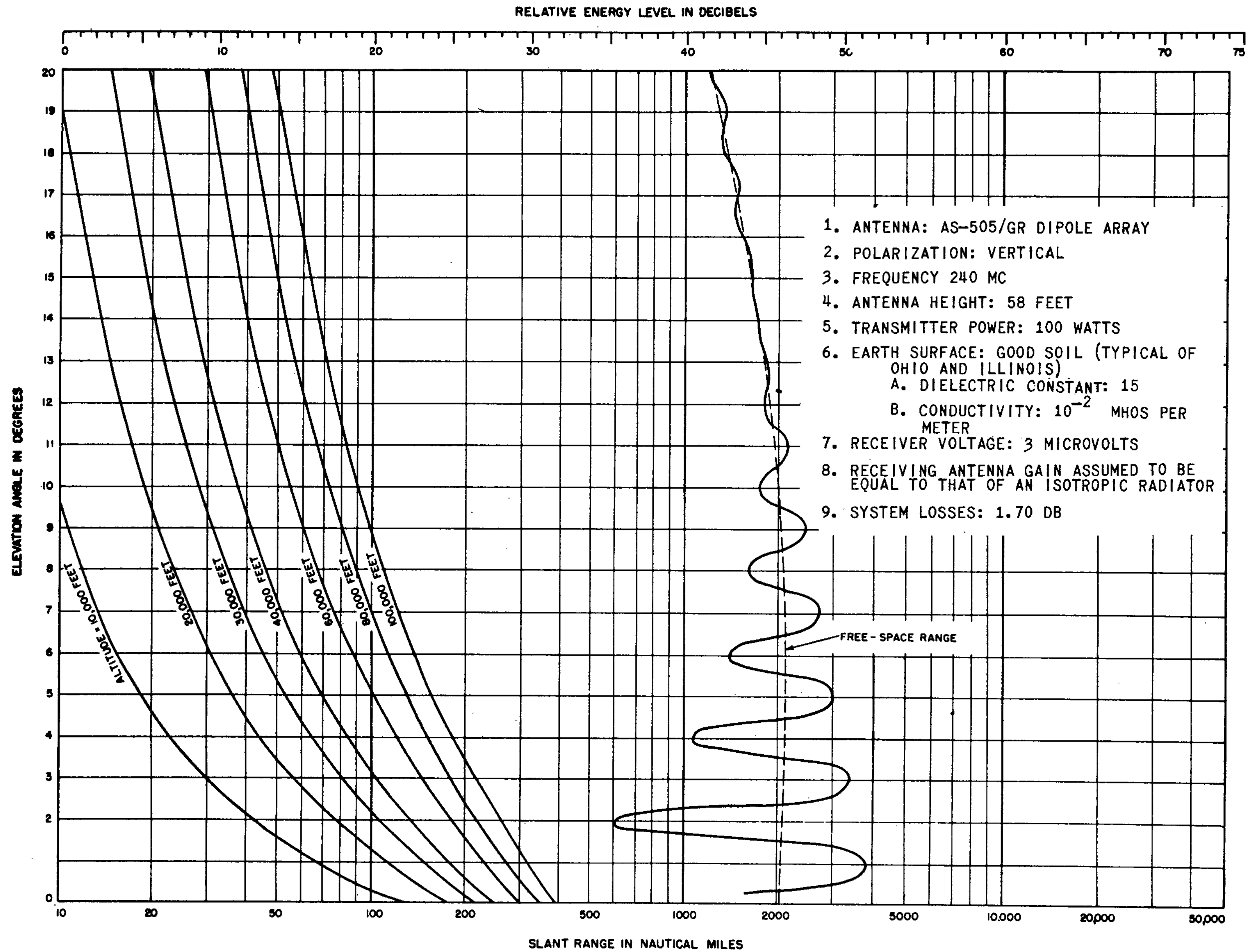


Figure 35. UHF Coverage Chart - Antenna AS-505/GR at 240 mc. Earth Surface: Good Soil

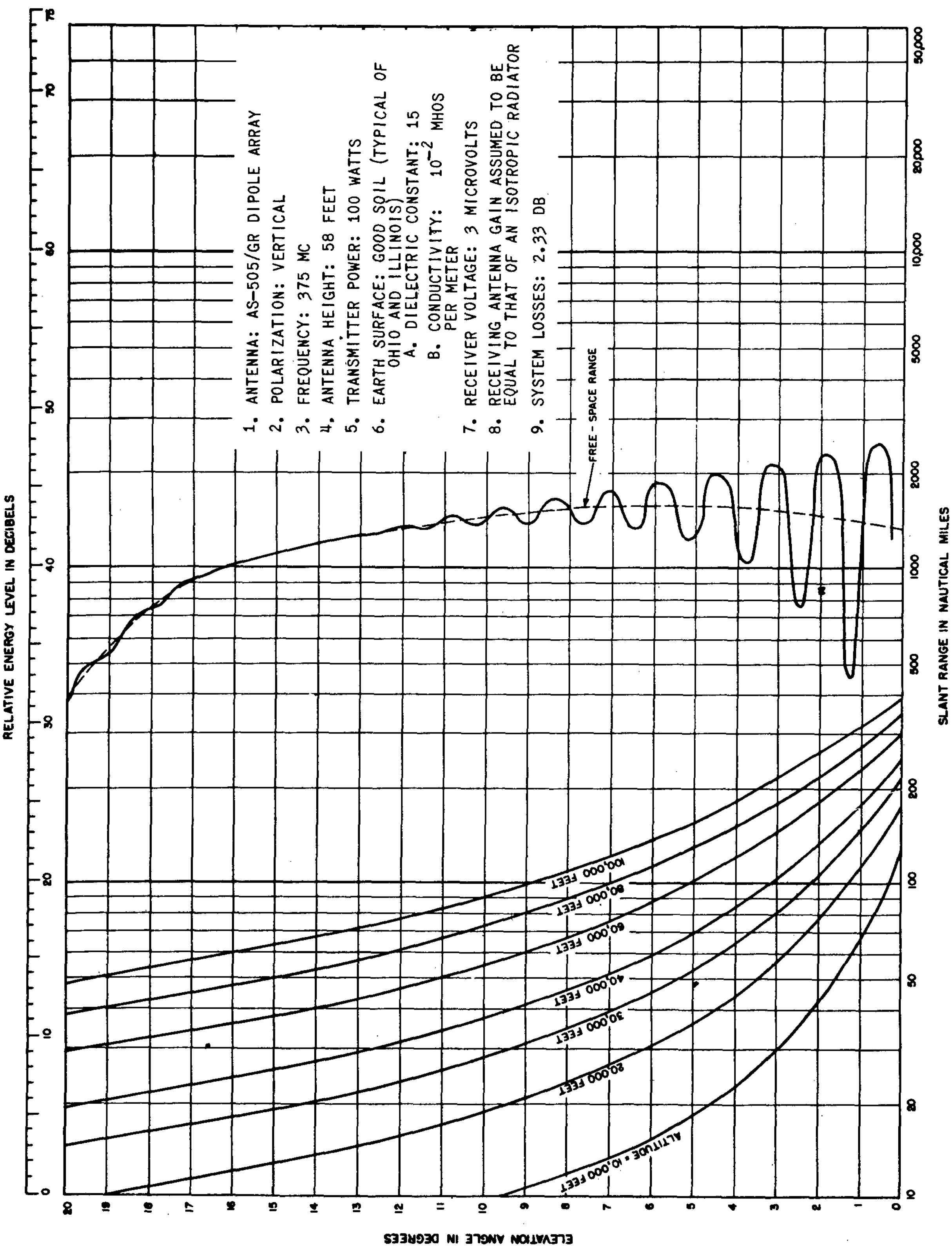


Figure 36. UHF Coverage Chart - Antenna AS-505/GR at 375 mc. Earth Surface: Good Soil

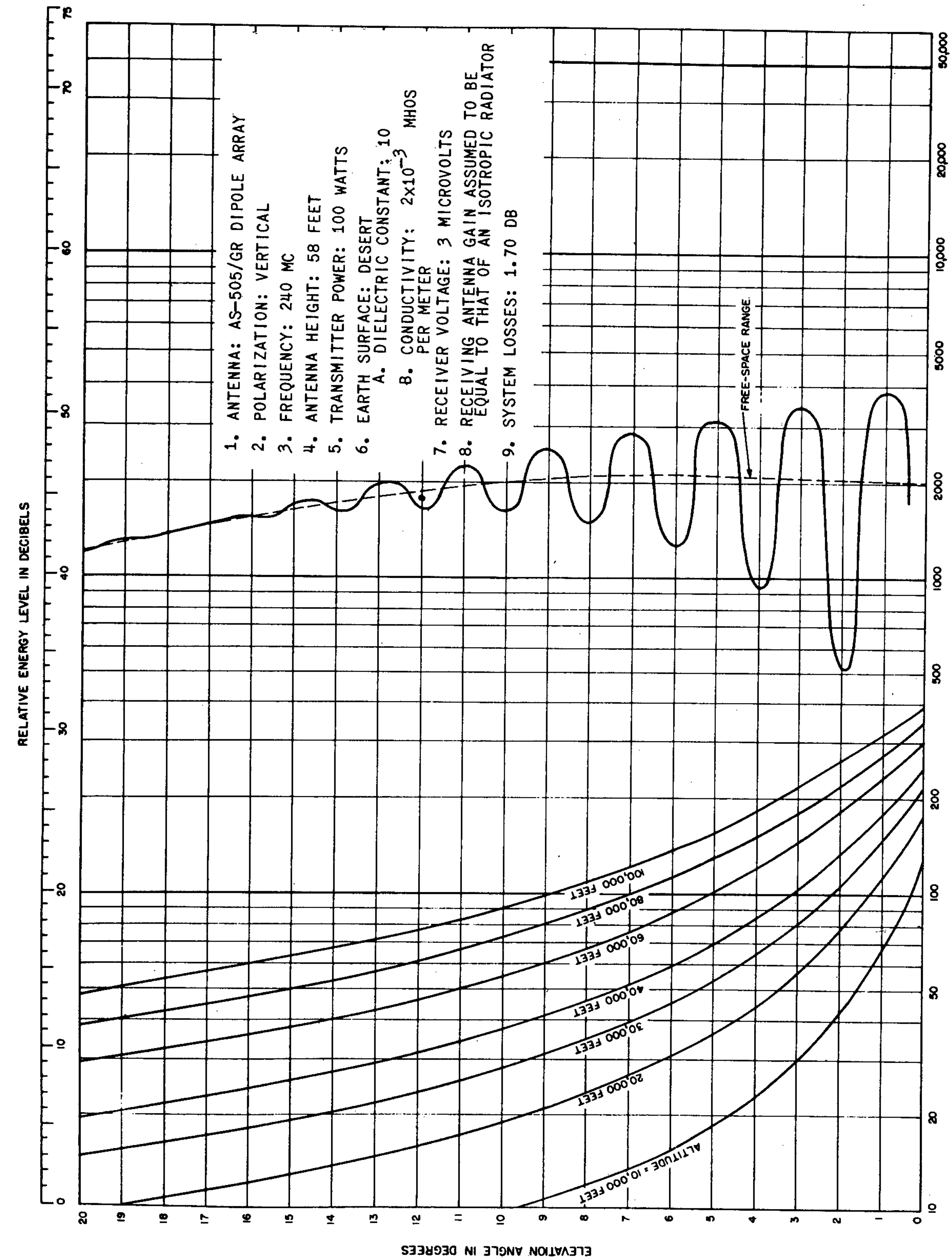


Figure 37. UHF Coverage Chart - Antenna AS-505/GR at 240 mc. Earth Surface: Desert

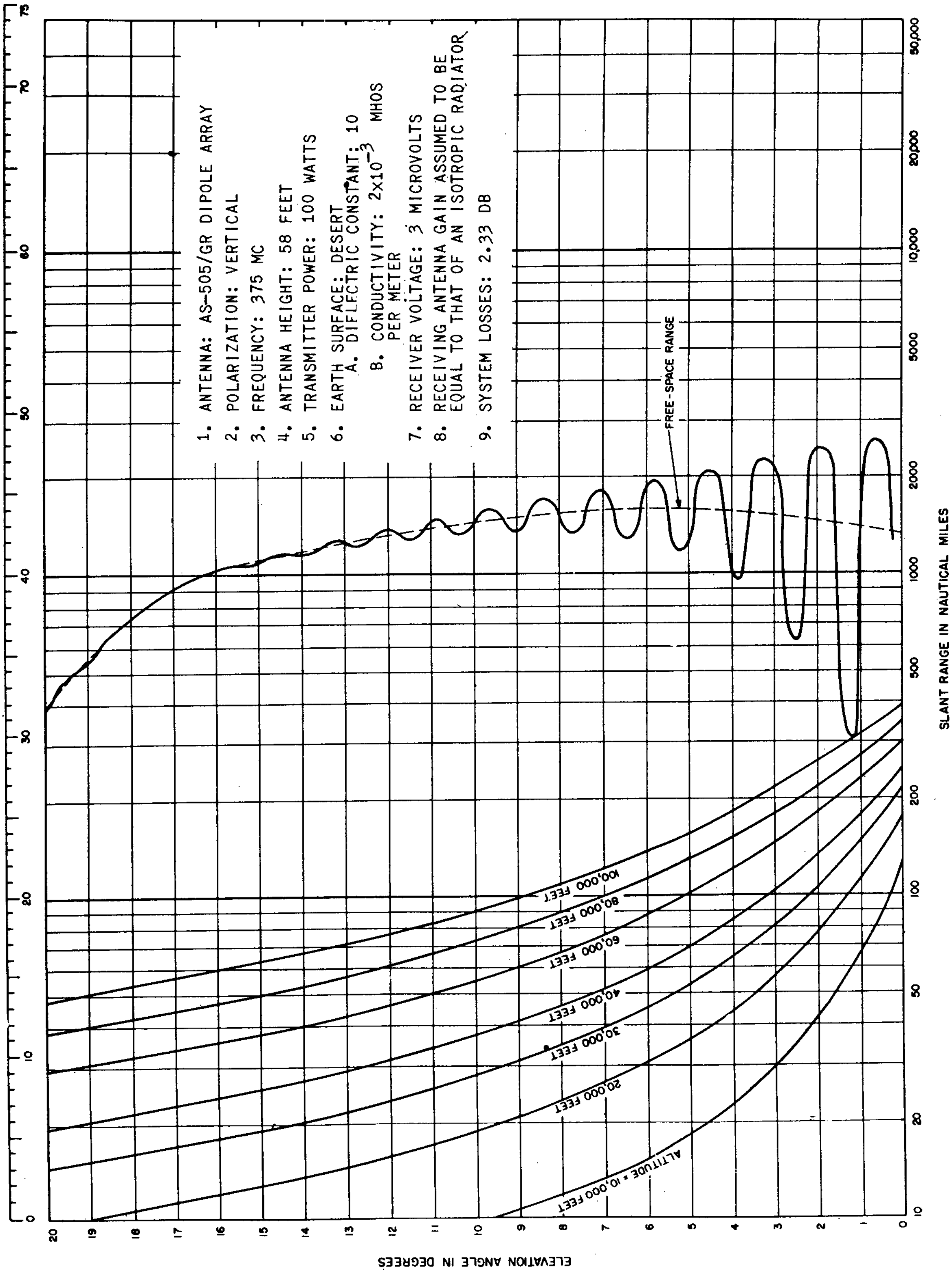


Figure 38. UHF Coverage Chart - Antenna AS-505/GR at 375 mc. Earth Surface: Desert

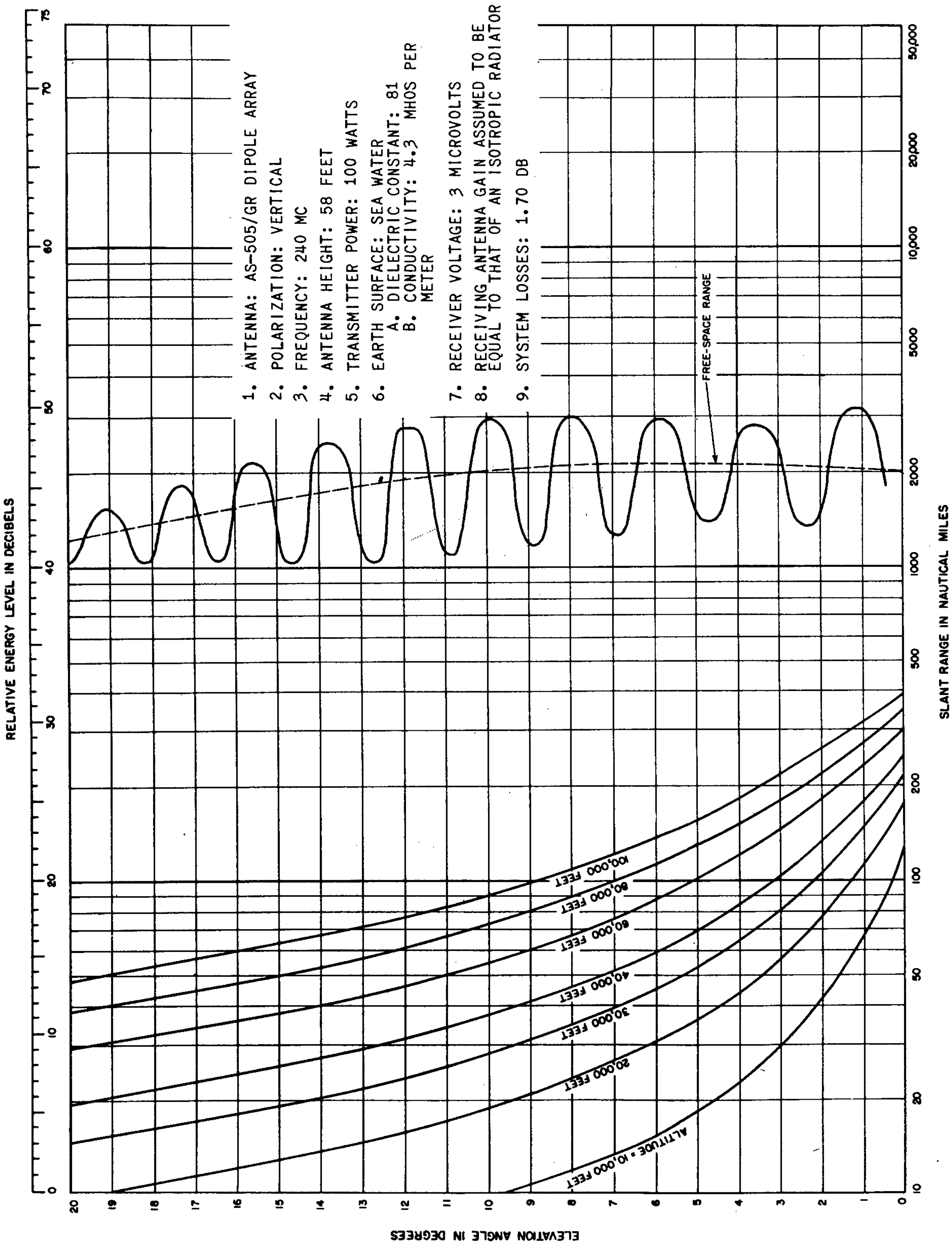


Figure 39. UHF Coverage Chart - Antenna AS-505/GR at 240 mc. Earth Surface: Sea Water

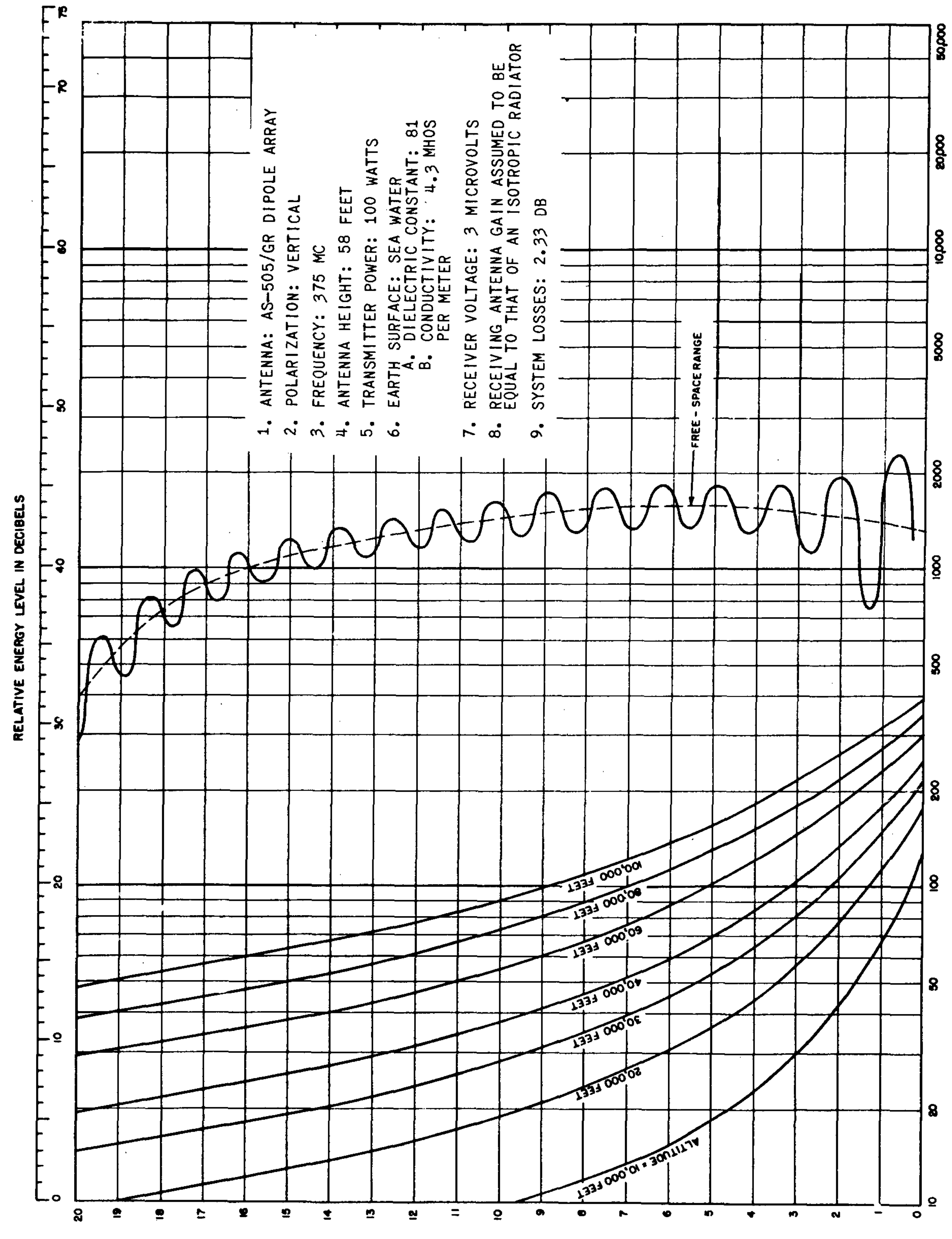


Figure 40. UHF Coverage Chart - Antenna AS-505/GR at 375 mc. Earth Surface: Sea Water

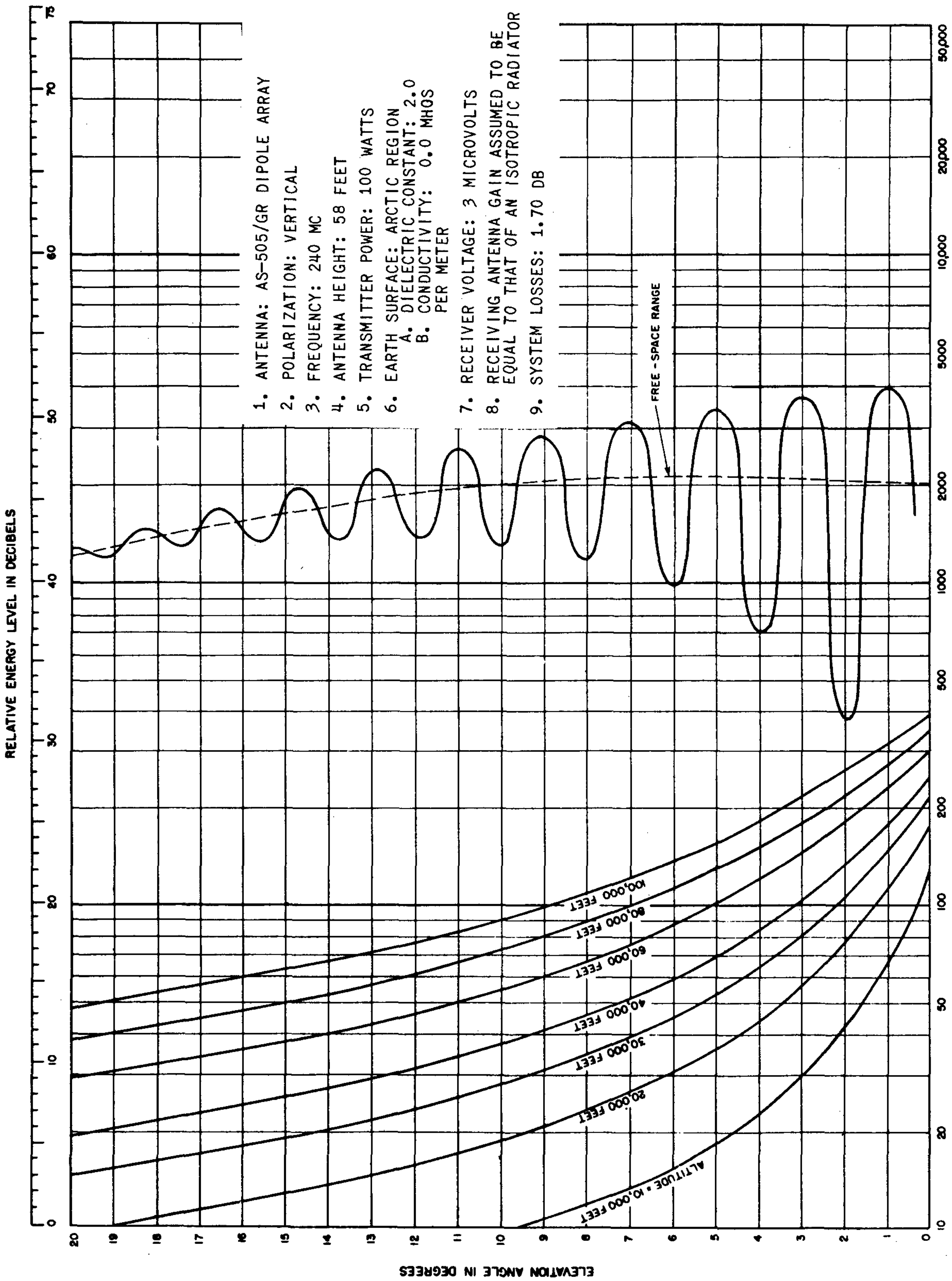


Figure 41. UHF Coverage Chart - Antenna AS-505/GR at 240 mc. Earth Surface: Arctic Region

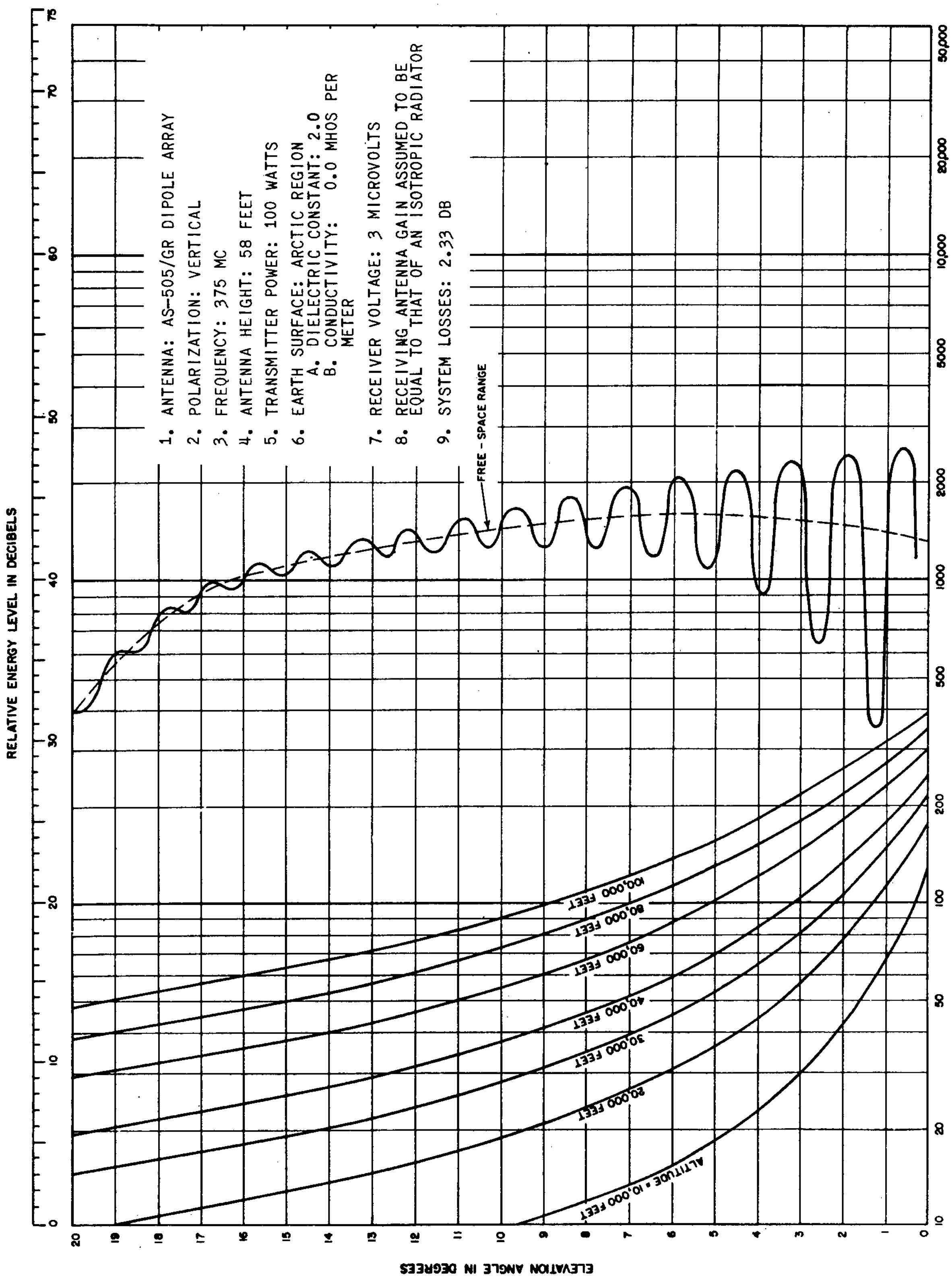


Figure 42. UHF Coverage Chart - Antenna AS-505/GR at 375 mc. Earth Surface: Arctic Region

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